

THE CREATIVITY CHALLENGE:
MANAGEMENT OF INNOVATION
AND TECHNOLOGY

by MARTIN E. GINN



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*The Creativity Challenge:
Management of Innovation
and Technology*

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**MONOGRAPHS IN ORGANIZATIONAL BEHAVIOR AND
INDUSTRIAL RELATIONS, Volume 20 (Part A)**

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York State School of Industrial and Labor Relations, Cornell University*

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The Power to Create—Is Great!

*The Creativity Challenge:
Management of Innovation
and Technology*

by **MARTIN E. GINN**
*Stuart School of Business
Illinois Institute of Technology*

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Preface

A multifaceted subject deserves a multifaceted approach. That is the method used in developing this work. The main question was how to improve the management of technical professionals who are striving to develop new technologies, that is, new products and processes. In seeking answers, various dimensions of innovation were explored: looking at theory and practice, looking at macro and micro regions, and looking at initiating and implementing stages of the process.

This work evolves from the author's many years of industrial experience as a practitioner engaged in technological innovation and as a manager of research and development. It also evolves from research in the academic environment, and from teaching students about the field at graduate (MBA) and undergraduate levels. Some historical perspective is worthy of note. During 1973-1974 in the United States, the Energy Crisis interrupted what had been a period of prolonged economic growth and remarkably strong innovation that emerged from the Second World War through the 1950s and 1960s. Already, during the 1960s, the cynicism of the protest movement had raised questions about the merits of technological innovation as the dominant theme to be embraced by all. These factors, coupled with a weakening economic situation and the emergence of strong competitors, most notably the Japanese, resulted in some erosion of technological leadership by the United States. That erosion has proceeded into the 1990s. Beginning in 1992, there has been substantial improvement in the U.S. economy, and some weakening of competition from other countries, including Japan. The improvement in U.S. competitiveness is attributable to economic factors and to restructuring, but also to the unparalleled ability of the United States to reinvigorate its markets by developing and implementing *new* technologies. Advances in semiconductors, biotechnology, telecommunications, and the information highway are just a few examples of renewed or sustained U.S. leadership.

Competition is expected to continue at very high levels as we enter the twenty-first century. The recognition that major technology-based

societies, even eminently successful ones, can experience significant erosion of competitiveness and productivity has provided impetus for this work. Over the centuries whole societies and cultures which were once highly productive have fallen into decline. It is believed that some major part of those declines relates to a diminishing of ability to create the new technologies that would have provided stimulus for continued growth. That is why the term *The Creativity Challenge* is included in the title of this work. The challenge arises from a need to continuously work toward improving technological creativity when roadblocks are generally increasing. Underlying the approach taken is the central assumption that improved management skills are needed to promote and sustain the needed growth. Without continuing improvement, momentum is lost. Deterioration results.

The management of technical creativity underlies the entire process of innovation and is a major theme of this book. That theme is addressed through various mechanisms: by developing theory and decision models, through seminal interviews of practitioners and technology managers, by examining case histories of innovating organizations, and through minicase simulations of real world experiences. The minicases have been found to be an effective tool for increasing understanding of innovation dynamics and for promoting the building of teams in organizational settings.

In addition, two empirical research studies are summarized in this work. One study involved the measurement and analysis of barriers and facilitators that were experienced by significant innovators during the creation of new technologies. Many successful and unsuccessful projects were accessed in deriving data for that study. The second study attempts to better understand how differing cultural perspectives in two quite dissimilar societies can help to explain the widely differing levels of technical creativity that have resulted. That was accomplished by comparing responses to minicases that were introduced to matched samples of individuals in the People's Republic of China and in the United States. Both studies were found to support the theories and decision models proposed in this work.

One of the primary motivating factors behind this work was to examine the process of technological innovation at various levels, including macro, micro, and intermediary levels, to understand how to better manage that process. This accounts for the sequencing of the material. First, the book covers macro issues of strategic management and international competitiveness. Micro issues of creativity management are then examined and those issues are connected with organizational culture. Then the book considers organizational structure and intermediary levels of technology transfer within and outside the organization. That brings us back to an examination of issues in the international domain.

Another strategy was to include practitioners from industrial, academic, and governmental sectors, without attempting to distinguish perspectives

between the sectors in any formal fashion. Certainly, differences exist. Industrial researchers are more focused on applied research, academics are more focused on basic research, and government researchers are more focused on issues of national interest. But similarities of perspectives are considered to far outweigh the differences. Much basic research has been done, and continues to be done, within private business enterprises. Academic institutions have been focusing more on deriving practical solutions that are theory-based, in addition to the purely theoretical pursuits. And facilities engaged in governmental research have become more involved in technology transfer to find commercial applications for evolving technologies. Accordingly, inputs of practitioners from all of these sectors are considered relevant and are included in this work.

The work also attempts to balance theory or expository material with empirical observations by including practitioner interviews, major case studies, and experiential minicases. Backgrounds of the distinguished interviewees are interwoven within the interviews or may be found in the biographical supplement toward the back of the book. The empirical side of this work is intended to complement and give a greater sense of reality to the theoretical or textual side. The theoretical side provides useful perspectives for understanding and analyzing the "real-world" situations. Presenting one side without the other would seem to be weak or boring at the very least. Including both seems to provide a more powerful synthesis. This accounts for the adopted strategy.

Beginning with Chapter II, major *case studies* are introduced after each chapter. For the most part, the cases represent actual organizations that were engaged in developing and implementing new technologies by creating new products and processes. The organizations were accessed through the individuals who were actually involved in managing and carrying out the innovations. That strategy made it possible to *capture* the organizational cultures that were operating. The case studies are used to illustrate the concepts and principal themes of this work and to provide empirical support for those concepts. Understanding that people do change within organizations, and that perspectives may change as well, the dates of the interviews are reported in this work. The research for interviews and case studies spanned from 1988 to 1993. While the times and some of the "players" within the organizations do change, it is believed that the evolving theory of this volume is sufficiently "robust" to stand the test of time. Accordingly, the case studies are presented as "snapshots" which reflect and support the theories that are evolved. A short synopsis of each of the 11 case studies follows.

The first case, *General Electric Research and Development Center: A New Funding Approach*, serves several purposes. It introduces a wide range of technologies that have evolved throughout the twentieth century and includes the thinking of some of the individuals who led the development

of those technological advances. This case also deals with specific questions relating to funding of research and development (R&D), including the proportions of exploratory versus directed research that should be sustained in pursuing the purposes of the innovating organization.

Case 2, *Comdisco Disaster Recovery Services (CDRS), Inc.: What if?...* describes an organization that experienced incredible growth by pioneering important services and products in support of computer operations. At the time of this case, the company was pondering issues relating to what strategies it should pursue in advancing to the future.

Case 3, *On Thinking About Green Products*, includes perspectives relating to some important environmental issues. A debate on promotional claims and labeling protocols for consumer products provides a vehicle for developing those issues.

Case 4, *Peapod Delivery Systems Inc.: An On-Line Computer Service Innovation*, examines a new start-up, entrepreneurial organization that is operating in the service sector. The case elaborates some of the major issues it has been addressing in plotting its marketing strategies.

Case 5, *Dean Foods Company: Easy 2%*, traces the development of a new product in the consumer foods industry. The case illustrates some dynamics of interactions between marketing and R&D, and between marketing pull and technology push, that are experienced in innovation.

Case 6, *Neutrogena Corporation: An Imperative for Action*, considers organizational issues in new product development for a major manufacturer of personal care products. At the time of this case, the firm was trying to reposition itself in order to achieve substantial growth in sales and profits through innovation.

Case 7, *Patent Products Corporation/Yankee Bicycle Company: "Good Olde Yankee Ingenuity,"* taps into the thinking of an entrepreneurial inventor who is describing his operations. The individual is pondering whether his organization should be a patent development company, or a manufacturing company, or some combination of both.

Case 8, *ITW: Creativity and Culture*, describes the development of a rich culture that has evolved at a highly successful, innovative company. A key question emerging is how to ensure the continuation of that culture as the organization moves forward and develops further.

Case 9, *Inland Steel Industries: A New Organizational Initiative*, examines a new organizational configuration which is aimed at improving the implementation of new product and process technologies in operating environments. This initiative was introduced at a time when the organization was also repositioning itself for renewed growth.

Case 10, *Stepan Company: A Process Innovation*, focuses on technical creativity and innovation within a company that manufactures a wide variety of chemical specialties. The introduction of a new process for manufacturing

an important new class of products is described. This case provides a vehicle for exploring some interesting dynamics between R&D and manufacturing in achieving technology transfer *within* the organization.

Case 11, *Dalian University of Technology: Enterprise Managers Program*, describes a joint educational program aimed at promoting improved technology management practices in the People's Republic of China. The case provides an opportunity to examine cultural perspectives of this important country and to consider some questions relevant to technology transfer *across* international boundaries. The findings from the minicase survey are included in this case.

Some comment on style of presentation is also appropriate. In both the case studies and the individual accounts of practitioners or managers of technological innovation, an interview style is used to present the perspectives. That style was chosen because it seemed to best capture the "spirit and flavor" of the perspectives. The style also offers "windows" into the operating cultures of the various organizations that were represented. Accordingly, throughout the book, the style shifts back and forth from a purely expository style to the interview approach. It is hoped that this chosen strategy will enhance both the readability and the content of the material.

The author is very grateful to all the individuals who gave so generously of their time by providing inputs for the cases and interviews and by reviewing various drafts of the material. Not all the interviews or discussions that were held could be included because of space limitations. The individuals who were interviewed or engaged in discussions are listed, with grateful acknowledgment, as follows: George N. Alexy, A. Louis Allred, Fred C. Anson, Charles R. Bauer, Robert W. Beart, Ralph J. Bertalacini, Herbert Blades, Theodore E. Brenner, Thomas A. Buckman, Clayton Callis, Marvin Camras, Carl S. Carter, Donald J. Cram, P. (Beni) Dasgupta, Irving Domskey, Jerry L. Edwards, Tzilla Elrad, Max Epstein, Richard J. Ernst, Ellis K. Fields, Cynthia M. Friend, Robert W. Galvin, Marvin Garfinkel, Zolton Gelb, Leonard I. Grossweiner, James A. Hartlage, Raymond R. Hipp, Darleane C. Hoffman, Royce Husted, Satoshi Ikuta, Porter Johnson, Eric Jungermann, Zheng Liu, Sharon B. Long, John P. Longenecker, James W. Longworth, Frank W. Luerssen, Junyan Luo, George Magnus, Rolf Mast, Richard I. Mateles, Shiro Matsuoka, Keith W. McHenry, David L. Morrison, Michael J. Morrison, Sheldon Mostovoy, George A. Muck, Sudhakar Nair, P. Ranganath Nayak, John D. Nichols, Charles L. Owen, George E. Pake, Andrew B. Parkinson, Thomas L. Parkinson, Kenneth N. Pontikes, Ron Rahorn, R. Scott Rambo, Charles C. Rayburn, Walter L. Robb, Frederick J. Rocchio, Jr., Ned M. Rockwell, Dave Rotunno, Alan Schriesheim, David P. Sorensen, Richard Townsend, P. Tyson (Ty) Stakes IV, Wu-Ki Tung, Darsh T. Wasan, Dhani Watanapongse, George Wise, Thomas Wolfram, Peter Wray, and Zengyao Zhang.

A few individuals were interviewed and provided data, but chose to remain anonymous; and still fewer individuals could not extend permissions for publication of their comments. The wishes of these individuals are respected with gratitude for the time they expended.

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Finally, to my wife, Diane, I owe the deepest gratitude for her willingness to type various drafts of the interviews, but mostly for her patience and love.

To all of the above, I am deeply grateful. As for the ideas expressed in this book, I assume full responsibility.

Martin E. Ginn

Chapter I

Introduction and Overview

First of all, it is important that a manager should have respect for creative professionals and their loyalty to their professions.

—Robert W. Galvin, Chairman of Motorola, Inc.

We opened up a whole new area for research. That's very satisfying.

—Cynthia M. Friend, Harvard University

International competitiveness has been intensifying. Weakening or recessional economies in the latter part of the twentieth century have made this period especially difficult for some of the major “players.” In the United States during the 1980s, there were burgeoning concerns over an apparent lagging of domestically-derived, inventive performance (Abernathy, 1982; Baily & Chakrabarti, 1988; Ross, 1985). An increasing number of U.S. patents had been authored by individuals residing in countries other than the United States. Glismann and Horn (1988) concluded that other countries were catching up to the United States in inventive ability.

For the United States, the situation appeared alarming since innovation and inventiveness have long been regarded as America's strongest assets—assets which are considered essential for economic health and competitive strength (Kanter, 1983; Tushman & Moore, 1988). Best-performing companies have been willing to launch new technologies (and products) while abandoning old ones in order to sustain competitive advantage (Foster, 1986; Levitt, 1988). The introduction and diffusion of novel, technology-based products is needed to fuel economic growth (Von Hippel, 1989).

Economic performance in the United States during the last quarter of 1993 was encouraging. The GDP growth rate increased to a level in the seven percent range compared to only about three percent the previous quarter (Hershey, 1994). There was evidence of growing strength in the U.S. economy. Productivity and competitiveness were improving, but problems relating to trade imbalances and low investment levels have persisted (Council on Competitiveness, 1994). Productivity has been increased to some substantial degree by decreasing the input side of the equation, that is, through a host of cost-cutting or downsizing mechanisms.

It remains to be seen whether productivity will continue to increase without substantially increasing the output side, as would be obtained from spurring on innovation and inventiveness through increased investments. There are some signs that the prognosis might be improving, but the issue remains in question.

If, indeed, a treasured distinctive competence of a culture is inventiveness, then one should be as concerned with better managing this “upstream” process as one is with downstream elements of innovation and commercialization. Yet, according to some, adequate management has been lacking; and even more alarming, a kind of complacency had emerged in the U.S. society which could be threatening to its long-term survival, at least at the levels of excellence to which we have become accustomed (Harrison, 1992, p. F11).

An increasingly more competitive and turbulent environment is anticipated for the twenty-first century (Huber, 1984). Such competitiveness requires that firms and participants will have to be more skillful in transitioning the stages of innovation. Greater flexibility in management will be needed as environments and operations shift and vary in structure.

When new products are successful, reasons for success arise from a variety of factors (Rubenstein et al., 1976; Cooper & Kleinschmidt, 1987, 1988). Accordingly, success in new product development or innovation derives from multidimensional inputs. If that is the case, successful managers will also need to be increasingly multidimensional, that is, capable of moving adroitly from one management subsystem to another. Such enhancement of management skills should promote greater quality of effort, and more rapid introduction and diffusion of new technologies (Utterback & Abernathy, 1975).

Brown and Karagozoglu (1989) have concluded that a systems model is needed for technological innovation, one which recognizes that there are forces which are positive (favoring innovation) and forces which are negative (retarding innovation). Inputs for key decision making and for implementation differ substantially in character depending on goals espoused (radically new products, incrementally new products, or process efficiencies), as well as on the stages involved in the technological innovation process. Duncan (1976) has postulated that ambidextrousness is important in innovating organizations and has provided contingency models that can be used in decision making. The nature of the contingent management structures depends on whether one is operating in initiating (organic) modes or in implementing (mechanistic) modes.

Concerns have also focused on the “micro-level” region of innovation, that is, at the level of the individual professional or inventor (Katz, 1988). The problem of identifying qualified individuals, early on, is very difficult according to Root-Bernstein (1989, p. 50), but can be addressed by looking

for the "rare individuals who are not only unusually broadly trained, but who have demonstrated that they can both think and do for themselves." Upon considering characteristics of creative (technical) individuals, it has been concluded that multidimensional, ambidextrous models are appropriate, not only for groups, but for increasing performance of creative individuals as well (Ginn, 1986a, 1986b). Such models should allow for dichotomous decision making, opting for structure on the one hand, and less formalization of structure on the other, depending on contingencies involved. Badawy (1986, p. 28) also noted, among various guidelines, the desirability of "balancing the need for freedom and the necessity of structure."

Evidence from the psychology literature also supports the strong contributions of seemingly contradictory elements in the domain of creativity. Amabile (1983, p. 362) noted the "apparently contradictory importance of both 'work' and 'play' in the motivation for creative behavior." Mumford and Gustafson (1988, p. 38) suggested that different contingencies or climates are appropriate depending on the radicalness of the creativity that is sought. More radical creativity drawing upon new knowledge requires more open structures and greater risk-taking; but incremental creativity which is strongly goal-driven requires more rigid structures and higher levels of control.

As a result of these contributions, we see an interesting combination of contrasting elements emerging. The elements include skills and personal abilities as well as structure and planning (Perkins, 1989, pp. 333-334). All are required and contribute to the ability to be successfully creative. The contrasting elements are considered to be especially important in domains of technical individuals who are striving to create new technologies.

Consistent with the importance of contrasting elements in creativity and innovation, we are seeing more and more suggestions in the management literature that organizational units should also be managed according to various contingencies. Appropriate management structures should be organic or mechanistic depending on the type of entrepreneurial behavior that is involved (Duncan, 1976; Slevin & Covin, 1990).

Given that these precepts are valid, it becomes important that formal and informal decision support systems be available to facilitate appropriate choices of operating modes, depending on the contingencies that are involved. An examination of decision literature suggests that decision making is a highly complex process involving many variables. March and Olsen (1986) have evolved a "garbage can model" to help understand the apparent disorderliness and randomness in decision making by managers. Trade-offs are continually made reflecting a high degree of interdependence among participant groups. According to Wilkof (1989, p. 185), "achieving a *balance* between controlling development activities on the one hand, and encouraging creativity on the other, is a complicated process." The

complexity suggests a need for models or paradigms that will facilitate decision making, considering the many options that are available during technological innovation.

MODELS AND DOMAINS OF TECHNOLOGICAL INNOVATION

Figure I.1 shows how a progression of developing new technologies, with related new products and services, can contribute crucially to an organization's ability to maintain returns on investment.

As organizations progress through innovation life cycles, three key phases need to be transitioned: (1) the planning or strategic management phase, (2) the technology creation phase (or new product R&D), and (3) the technology transfer stage. To these, we might add the technology maturation-dematuration-reformulation stage which begins the process anew. The curves given schematically in Figure I describe investment and profit-generating regions for three evolving technologies or new product families. Below the zero axis, where planning and product development is occurring, the

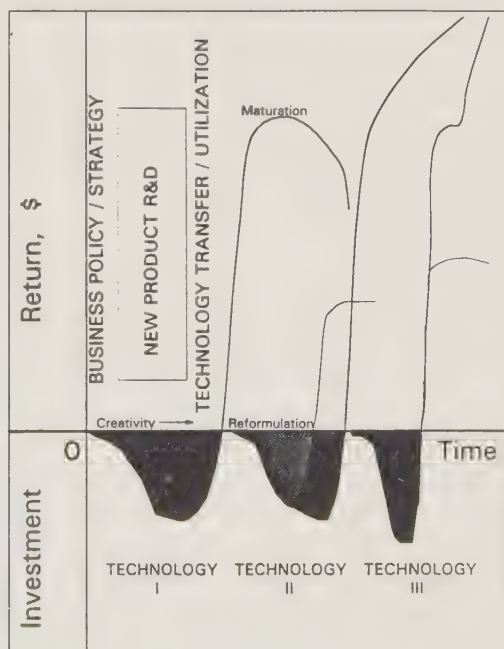


Figure I.1. Progression of New Product Technologies

organization is investing capital in support of various activities. New product R&D, the technology creation phase, is critically important as the initiation stage which determines the quality and success of all subsequent stages. Technological creativity, in a sense, operates like a *pump-handle* which drives the entire process. In this creativity stage, research and development is essentially interfacing with all elements of an organization's operating culture and infrastructure. The environment of research and development can range from being highly supportive to one that is alien, depending on the posture of the organization's culture to innovation. Skills of encouraging and managing technological creativity, through individual and group processing, are especially important in this region.

Above the zero axis in Figure I.1, the implemented new products and process technologies are generating returns on investment. Commercialization or utilization has been achieved. Given market acceptance, the curves continue upward until maturation or decline occurs. As competitiveness becomes more intense and technological obsolescence tends to occur earlier, the innovation curves tend to become more compressed in relation to the time line. Although not inevitable, maturation and decline tend to occur earlier as time progresses. New technologies must be introduced at faster rates in order to sustain growth of net income.

Innovating organizations must become increasingly more adept at managing transitions and in anticipating potential discontinuities and avoiding them by continuously developing new and improved products in a timely fashion. The stakes are high. One can see from Figure 1 that the inability to introduce a new revenue-generating technology, for example, Technology II, can have a very serious, negative effect on revenue flow. Any absence of required revenues also adversely affects an organization's ability to invest in future innovations. So discontinuities are doubly pernicious.

The process of technological innovation impacts on all levels of the organization and involves the interactions of multiple constituencies. The interacting elements include top management and the corporate infrastructure, departmental or functional groups, and the individual. In the dynamic environment of the twenty-first century, all levels in the innovating organization will need to contribute with appropriate commitment and motivation if the firm is to be effective. Performance will depend on a proper balancing of factors, with commitment and product championing arising in all levels of the firm. *Individuals* as well as groups are emphasized as key contributors in the innovation process. Along with group action, individualism has long been recognized as a distinctive feature of a creative culture. It is believed that the role of the individual will have new emphasis, perhaps a rebirth, as imperatives for technological creativity are recognized to greater extents. Managers will be challenged to be more skillful in managing diversity among

individuals, recognizing their individual talents and values and the importance of self-actualization. Sensitivity to values is a central ingredient for providing appropriate reward structures.

The basic approach of this text is to view management of technological creativity and innovation as a global process. As such, the field requires consideration of multiple domains. The "upstream" range of innovation is emphasized, since this is where creativity is most strongly evident. It is also important to examine issues relating to planning and strategic management and to consider "downstream" issues as well. Interactions occurring at pertinent organizational interfaces become critical during the implementation of newly developed technologies. Accordingly, it is perceived that an acceptable treatment of the topic encompasses three primary levels or domains (Figure I.2):

1. The Strategic Management Level including formulation *and* development of relevant strategies for implementation.
2. The Creativity Management Region where the individual, creative technologist, and collectivities of such individuals are especially important in the origination of new technology.
3. The Functional Group and Cross-Cultural Team Level within the organization, involving interacting subsystem elements of marketing, R&D, manufacturing, finance, sales, and the top management infrastructure.

The levels or domains of management in innovation are not intended to be distinctly separate. The domains overlap substantially. Accordingly, creativity and contributions of cross-cultural teams are important in strategic management, that is, in planning and implementation. Functional group members and creative individuals must be able to think strategically

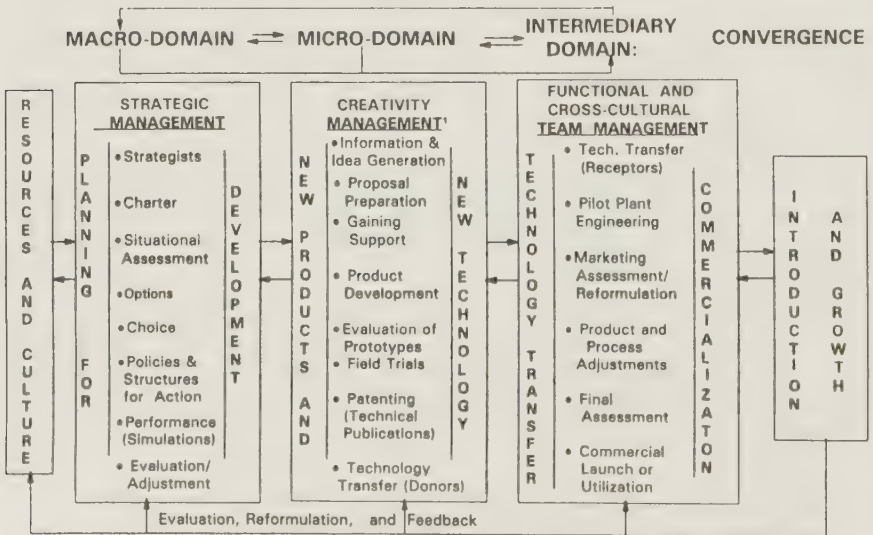


Figure I.2. Domains of Innovation in a Horizontal Flow Model

in order to connect their roles to the performance of the overall organization. Creative individuals must also be able to think and interact effectively with various functional groups and in cross-cultural teams in order to achieve successful implementation.

The domains of Figure I.2 are important since they represent the process elements which are the core of a systems model for new product development and technological innovation. The overlapping and interacting aspects of the domains are as shown in Figure I.3.

As process core elements, any dysfunctions or discontinuities in any of these managerial domains will adversely affect innovation efforts. Dysfunctions may lead to failure of key initiatives. All three areas must be managed effectively in order to be successful in introducing new products and technologies. It is also recognized that the systems and subsystems of innovation, and the relevant decisions that must be made, are operating in the context of the environment, with all the elements that are entailed. In other words, the systems are open.

In developing this multidimensional approach, *certain premises are adopted*, as follows:

- A general management perspective incorporating strategic management principles is considered appropriate at all levels of the innovating organization.
- Contingency management approaches are especially relevant in managing creative technologists.
- The creative individual is highly adaptive and flourishes in an atmosphere/environment which permits freedom of choice among pertinent alternatives.

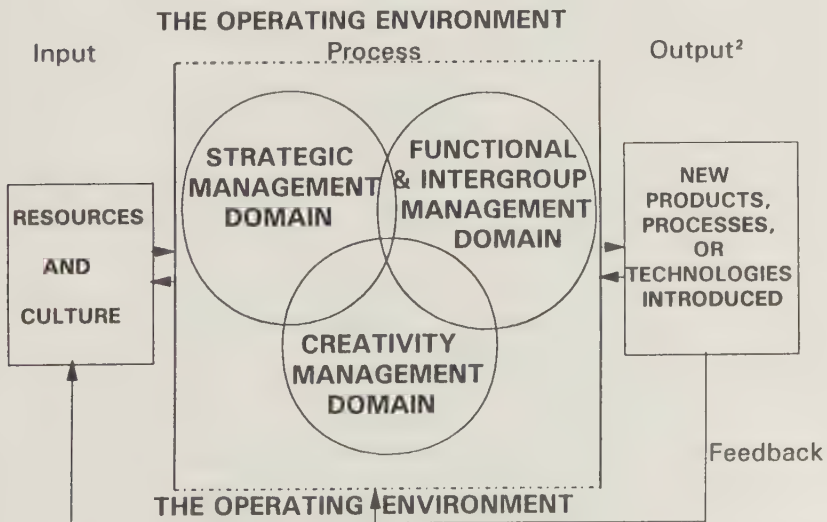


Figure I.3. Overlapping Domains in a Systems Model of Innovation

- The successful, technical professional will be a skilled scientist or engineer, possessing qualities of discipline and orderliness, yet also will possess substantial creative abilities. A substantial proportion of creative technologists will favor entrepreneurial or intrapreneurial approaches and, therefore, will serve as their own product or technology champions to a significant degree.

CONNECTIONS WITH SOME RELEVANT THEORIES OF ORGANIZATION AND MANAGEMENT

Since this is a management text, it is pertinent that we consider theories of management which are especially relevant to our perspectives. The relevant theories are wide-ranging and span from macro, to micro, to intermediary regions of management. A "road map" of some especially pertinent management theories is given in Figure I.4. The theory road map "connects" the various categories of thought in a logical progression, not necessarily chronologically, but as an evolving field which progresses from "universalism" to contingency theories then back toward universalism. Consistent with the ideas of Mintzberg (1983), it is believed that universalistic perspectives tend to be invoked when environmental imperatives must be addressed. Contingency management tends to be more evident when operational slack exists in the system.

First, let's consider some pertinent definitions:

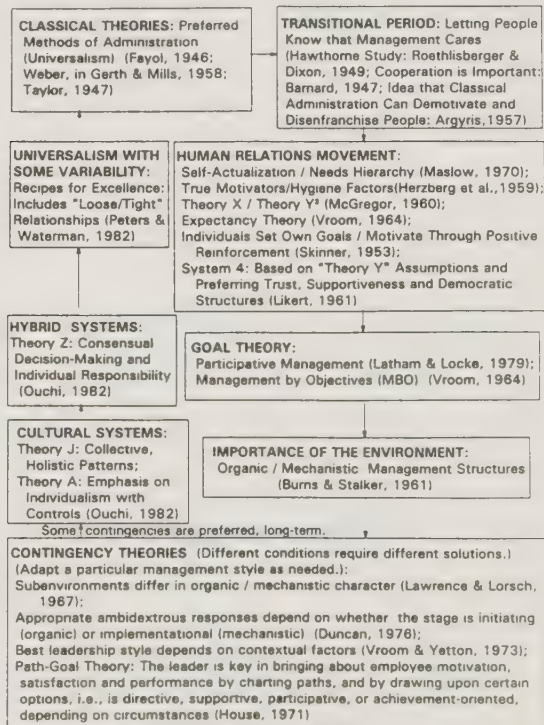


Figure I.4. Road Map of Relevant Management Theories

Universalism—represents the belief that there is “one best way” to manage. A best method of management is one, that if followed, will cause the organization to be effective (Dewar & Werbel, 1979).

Contingency theory—reflects the notion that the appropriate style of management is determined by environmental conditions, that is, by variables such as the situation, the task or technology, characteristics of the leader and characteristics of the followers (Dewar & Werbel, 1979).

Because of the variegated nature of domains of technological creativity, *both* perspectives are considered necessary for success. The flow diagram of Figure 4 is intended to suggest that each management theory is relevant at some point in time. By this notion, theories ordinarily regarded as universalistic become “de facto” contingency theories to the innovating practitioner. The notion that a variety of management theories are relevant in organization behavior is held by modern scholars in the field of behavioral science (Higgins, 1991).

“Classical theories” are fundamentally universalistic in nature as indicated by the first classicist, Fayol (1946). By including such elements as order and discipline, unity of direction, and delegation of authority, his 14 principles of administrative management embody many elements that would be readily embraced by a professional scientist or engineer.⁴ The 14 principles were intended to be valid under all circumstances which might be encountered. The principles are strongly “mechanistic,” that is, suggest environments which are highly structured and centralized, where top-down decision making is the norm. Upon examining Fayol’s principles, a management-centered approach is clearly operating, where senior managers in positions of authority would be advising more junior subordinates on how to manage their affairs to best promote the organization’s interests as well as the interests of their profession. That aspect is consistent with a commonly accepted perspective that experienced, successful scientists or managers should serve as *role models* for less experienced individuals who are still learning the field. The elements within the principles also reflect orderly and ethical standards which are common as operating protocols among technical professionals who tend to be fairly disciplined by nature.

Two other classical theorists, Weber (contributing rules of bureaucracy) and Taylor (operating through scientific management), recommended protocols that are appealing to technical professionals. Weber emphasized an ordered, objective approach in management, one that favors conducting business impersonally and bases advancement on technical expertise rather than on favoritism (Gerth & Mills, 1958).⁵ Taylor (1947) emphasized scientific protocols for maximizing work efficiency, with both management and the worker being accountable. Scientific method and good investigative practices have ongoing importance among scientists and engineers.

The “transitionalists” helped to move thinking from a purely management-centered focus to the employee or individual-centered focus of the Human Relations School, an important perspective for technical professionals. Roethlisberger and Dixon (1949), in their description of “the Hawthorne experiment,” opened up management thinking to recognize the motivational importance of communicating concern for the employee’s interests. Barnard (1947) viewed organizations as cooperative systems in which management needs to gain acceptance of authority and where both management and employees (individuals) need to work together toward achieving common goals. Argyris (1957, p. 234), in a sense, drove the transition further by suggesting that individuals will become increasingly passive and dependent when classical approaches give permanence to directive leadership and the use of rigid management controls. Since individualism and motivation are important themes in innovation, the ideas of the transitionalists are highly relevant.

The Human Relations School injected a social context between the work situation and the worker response. McGregor (1960) distinguished between “Theory X” traditional assumptions that workers tend to be unprofessional if undirected and a “Theory Y” human relations orientation, in which workers are generally assumed to be professional and responsible.⁶ In order to promote organizational performance, McGregor favored the Theory Y perspective, believing its use would enhance organizational performance. The Needs Hierarchy Theory of Maslow (1970) placed self-actualization as the highest level of need, followed by self-esteem, in ranking motivators of human achievement.⁷ Maslow considered all individuals to be capable of creativity to some degree. Herzberg, Mausner, and Snyderman’s (1959) Two-Factor Theory identified hygiene factors, such as good physical surroundings and reasonable salary policies, to be demotivators if absent, but felt that the true motivators were intrinsic factors such as the work itself, the opportunity to self-actualize, the experiencing of recognition, and so on. Self-actualization is a powerful motivator for engineers and scientists. Achievement motivation has been shown to correlate strongly and positively with entrepreneurial success and economic growth (McClelland, 1961).⁸

The Expectancy Theory of Vroom (1964) also contributes to our understanding of motivation and is relevant to the behavior of creative professionals. According to Vroom, motivation occurs more strongly if individuals perceive a likelihood that their efforts will lead to successful performance, if that performance will trigger a reward, and if the anticipated reward has a high value to the recipient. Expectancy Theory therefore places a premium on the importance of developing the knowledge and expertise that would be required in technological innovation. Since fields are generally expanding, life-long learning becomes the norm for technical professionals. Management plays an important role by encouraging and

providing access to various knowledge bases. Positive reinforcement represents an effective mechanism for providing encouragement and is similar to the practice of recognizing individuals for constructive performance (Skinner, 1953, p. 185). The reinforcer may be an added tangible enhancement such as a prize or a bonus; or it may be a simple, intangible comment of recognition by management, such as, "good job," "nice going," etc. In practice, these comments are referred to as "Attaboys." A favorable environment is one that encourages autonomy, individual goal-setting, self-measurement, and recognition from others for the achievement that accrues. With properties such as high levels of support, trust, confidence-building, participation, competency, and cooperation, Likert (1961, pp. 237-248) distinguished the System 4 organization as highest in effectiveness and espoused its use. Qualities of open communications, decentralization, and the setting of ambitious goals (Likert, 1967) suggest a close similarity to an organic management structure (discussed below), which was found to be characteristic of innovating organizations.

In "transitioning" further from the Human Relations School to Contingency Theories, we draw upon the works of Latham and Locke, Vroom, and Burns and Stalker. Latham and Locke (1979) emphasized that goals are natural and necessary and lead to higher levels of achievement and productivity provided they are realistic, comprehensive, meaningful, and formalized. Vroom (1964) noted that different people have different types of needs, desires, and goals and make decisions based on the perception that a given behavior will lead to goal-attainment. With Management by Objectives, Vroom provided a discipline by which individuals could readily participate in the process of setting goals. By evoking participation, these approaches opened up management systems to allow for contingencies, which would be considered desirable by technical professionals.

Use of Contingency Theory is one of the main support structures of this work. Burns and Stalker ([1961]1971, p. 119) provided a bridge to Contingency Theory by identifying two basic operating systems or environments of management, "organic" for innovating organizations, and "mechanistic" for organizations producing highly repetitive goods and services.⁹ Woodward (1965) found relationships between the manufacturing technology of an enterprise and its management system, and supported the Burns and Stalker typology by showing that organizations operating mass-production methods tended to be mechanistic and controlled, and those operating unit or small batch or continuous process methods tended to be organic and flexible. This notion of different operating environments was extended to subenvironments *within* organizations by Lawrence and Lorsch (1967). Lawrence and Lorsch distinguished Manufacturing or Production, with relatively short time horizons, as being mechanistic and R&D, with longer time horizons, as being organic in character. As a result, the dynamics

of transferring technology from one functional subsystem to another could be explained by considering pertinent subcultural aspects (Ginn & Rubenstein, 1986). These various typologies provided a solid foundation for the use of contingent postures in the management of innovation.

Contingency or situational theories have been extended to many areas of management, including to methods of leadership by Vroom and Yetton (1973), Fiedler (1967), Fiedler and Garcia (1987), and House (1971). These approaches are based on the assumption that appropriate styles of leadership depend on a variety of factors, for example, the situational context, the task or technology involved and/or the characteristics of the leaders and followers. Because of their flexibility, such assumptions are considered to be especially relevant in the domain of technological innovation where professionals are involved. An ambidextrous contingency model has been suggested for use in choosing between organic forms or mechanistic forms, depending on whether one is operating in the initiating stage or in the implementing stage of innovation (Duncan, 1976).

In view of the expanding nature of international business in the 1980s and 1990s and beyond, the cultural environment has become an increasingly important factor which influences management of innovation. Ouchi (1982) has noted differences in organizational approaches among various countries, for example, Type A (traditional American) and Type J (traditional Japanese), and has recommended a hybrid Theory Z approach for increasing U.S. competitiveness. In relative terms, traditional U.S. firms tended to be short-term in perspectives, highly specialized, explicitly controlled, with a fairly strong emphasis on *individual* decision making. Type J organizations tend to be long term in orientation, implicitly controlled, non-specialized, with extensive use of collective or consensual decision making. The Type Z organization focuses on the long term with moderate specialization of career paths, and also draws upon consensual decision making, but with an emphasis on individual responsibility. With the assumption that certain generic responses may be appropriate on a continuing basis in certain cultures, we begin to shift again in our thinking back toward a more universalistic perspective. That shift is perhaps furthered by a consideration of the Peters and Waterman (1982) work and its focus on attributes of excellence. Based on extensive research of companies having a prolonged period of sustained growth and success, Peters and Waterman identified certain characteristics which could be used by other organizations that were striving to be excellent.¹⁰

In reviewing some of the important management theories, a framework has been suggested that involves a shifting of perspectives from pure classical approaches to human relations approaches to contingency approaches and some movement back to more universalistic thinking. Such shifting may arise in practice because the environment of competition and innovation

is always changing. In the late 1980s into the 1990s, environments of innovation became more difficult because of the recessional economic forces. Simultaneously, competition continued to increase ever more fiercely. This may have triggered a subtle shift to more universalistic, more controlled, more monolithic perspectives. Further shifts will be experienced as operating cultures and subcultures gear up to become more creative and more innovative. For the long term, and especially in the domain of technological innovation and creativity management, the ability to be flexible will continue to be desirable. Participants will need to be able to shift and respond to new opportunities in new ways, while retaining a constancy of important values. Accordingly, the adopted approach considers each and all of the described management perspectives as potentially appropriate at various points in time.

FOCUSING THEORY TO INTEGRATED DECISION MODELS

In this section, a multilayered decision model is proposed. The model is based on the assumption that a balancing of approaches, employing dichotomous choice systems, is appropriate given the supporting theory (Ginn 1986a, 1986b; Ginn, Burnstein, and Townsend 1987). The model is introduced at this point to provide a framework for expanded discussion in subsequent portions of text. First, we examine a “real-world” scenario which encompasses several important issues (Ginn, Burnstein, & Townsend, 1987, pp. 430-431).

Composite Field Scenario—“The Uncommon Denominator”

An R&D group in a corporate research facility was requested by operating division personnel to help counter a major competitive threat. Competition had introduced a novel detergent which could “disperse soils better and faster” than any other product to date. It was touted as being a landmark development—the traditional scientific breakthrough. In promoting the product, competition explained that its mechanism of action derived from its unique ability to give a minute but significant charge to soil particles residing on a surface. Because of this charge effect, the soil particles were found to roll up into tiny droplets and then disperse into the wash solution. The result was speedy removal from the surface. The repulsion of soil droplets also helped by dispersing the particles throughout the washing solution. Competition was awarded a patent based on the use of the complex salts. Testing by the operating division personnel confirmed an unusually high level of cleaning by this concept. However, they were not able to formulate an equivalent product while avoiding the patent claims.

Several high level meetings were held because of the threat of this new development to existing market share. Corporate R&D was given the charter of coming up with a new formulation which would match competition in performance. The allowed time frame was incredibly short. Only 90 days were given to design and test a functional prototype. A cross-functional project team was organized, incorporating the best talent available, with outreach to eminent consultants. Given the high priority, full team meetings were held on a weekly basis to review results and update strategy. The basic approach in formulation was to screen additives which had any potential for activity, hoping that a "window" could be found to avoid infringing competition's patent. Virtually everyone agreed that there was not sufficient time to look for a fundamentally new approach, so the team would have to use the information in competition's patent as a starting point in development.

One R&D supervisor attended the meetings and seemed to go along with the group's thinking. However, the supervisor had some persisting reservations which arose from the following questions: Why try to emulate competition's product when it already is protected by a patent? Why try to copy a product when chances are that only parity would be achieved, considering that competition may already have improvements on the "backburner?"

So quietly—and alone on nights and weekends—the R&D supervisor began to look at totally new approaches. Basic questions were asked, like: "What are we trying to do? What other mechanisms might work? How can we test these concepts?"

As a result of these questions, the supervisor began to recognize that a relatively new kind of detergent molecule might offer the required properties. The key linkage in the discovery was the assumption that cleaning agents which tend to dissolve fatty soils might be unusually effective because fatty soils tend to glue soil particles to a surface. By this concept, one would not emphasize introducing complex salts but would stress the use of uncharged detergent molecules to dissolve the fatty soil. This type of thinking was virtually ridiculed by the group because it seemed to be a throw-back to theories which were "old-hat," and ran counter to more recent popular theories.

The R&D supervisor continued on, first in opposition to the group, "bootlegging" research time. But as the results became more and more exciting, support grew. Others were added to the effort. What evolved was a product which was markedly superior to competition's offering. The new formulation was patentable in its own right.

A prototype was developed within the 90 days. The company then proceeded with a scale-up and a successful introduction into commercial production.

Certain elements can be gleaned from the above composite scenario, as follows:

1. Under constraints of time, groups can tend to adopt pedestrian approaches and may pursue these with persistence and solidarity even though they may not provide needed solutions.
2. There may be a singular requirement in projects to allow for decoupling from group consensus and from the operating culture of an organization, particularly when the goal is to derive *entirely new*, technologically-based products.

The above scenario is not intended to undermine the importance of group involvements in the process of innovation. Groups are vitally important at various stages of planning, development, and implementation. Rather, we

*Table I.1. Key Decisions at Three Levels of Technological Innovation*¹¹

<i>Level or Domain</i>	<i>Decisional Dichotomy</i>
A. Strategic	I. Information gathering vs. Deciding II. Long-term vs. Short-term horizon III. Offensive vs. Defensive strategy IV. Technology push vs. Marketing pull orientation V. Risk-embracing vs. Risk-averse strategy VI. Internal vs. External focus
B. Behavioral (Creativity Management)	I. Expanding options vs. Converging II. Decoupling from culture vs. Connecting with culture III. Processing as an individual vs. Involvement in teams or groups IV. Structure vs. Unstructure (Mechanistic vs. Organic structure) V. Emphasizing intuition vs. Emphasizing analysis VI. Non-directive vs. Directive leadership
C. Functional	I. Gathering information vs. Resolving issues II. Bottom-up vs. Top-down venturing ¹² III. Manufacturing for design vs. Design for manufacturing IV. Cross-cultural team format vs. Functional orientation V. Defer launch vs. Launching as scheduled VI. Dematuration and renewal vs. Continuing present focus

wish to refocus attention on the individual in order to suggest a more balanced approach in management. In the realm of creativity, individual motivation, feelings of self-actualization, and the appropriateness of reward systems are especially important factors. Creative individuals may perceive that the opportunity to work as individuals, as well as in groups, constitutes a reward which satisfies their basic needs. That opportunity may lead to higher job satisfaction. Katz and Allen (1985) have suggested that higher project performance results when certain managerial influences are balanced, rather than being purely monolithic in nature.

Some key assumptions are made in viewing innovation and creativity management. First, it is assumed that appropriate styles of management depend on the stages involved in innovation, and even on situational attributes within each stage. Secondly, product life cycles are being compressed so that situational needs are changing more rapidly than ever before. As a result, managers need to be more sophisticated and flexible in addressing an expanding variety of situations. And finally, from our knowledge of creativity, it should be recognized that at certain times, inventors and researchers need to decouple from traditional cultural patterns in order to derive products which are radically new. Such products provide opportunities for being "first-to-market."

Because of the described complexities and relationships, the management of technological creativity and innovation involves all levels of the organization. To be effective, participants need to be able to operate in environments of change where many decisions have to be made on a frequent basis. Table I.1 lists some of the key choices or dichotomies that are considered important at the three levels of innovation, the strategic level, the behavioral level, and the functional level.

All of these decision dichotomies influence the operating environment in some significant way. The organizational culture influences these decisions and, in turn, is shaped by these decisions. In order to operationalize and facilitate the decision making process, the dichotomies and relevant selection criteria are incorporated into a multilayered model which is elaborated for the three levels in the following section.

Configuration of the Integrated Decision Models

Strategic Level Decision Dichotomies (Level A). At the strategic level, fairly broad issues relating to operating policies need to be pondered and decided, not only on an organization-wide basis, but on a technology-by-technology basis, depending on the resources at hand. The resources include the human component. Decisions made at the strategic level determine the nature of the macro environment, which determine the nature of the micro environment. It therefore becomes important that technical professionals

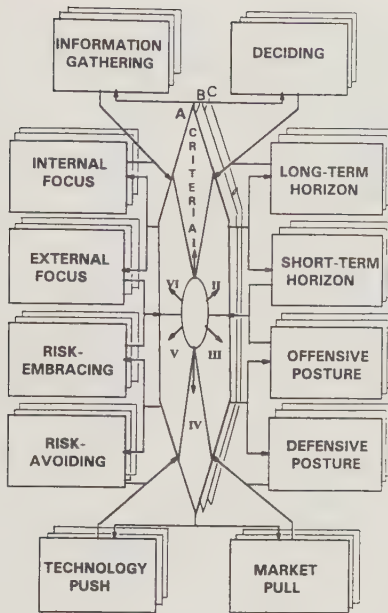


Figure 1.5. Integrated Model for Decisional Dichotomies at the Strategic Level

be able to participate as much as possible in the strategic process, at the very least, by being able to provide inputs for serious consideration.

We begin our discussion of the three-level paradigm with Figure 1.5 which focuses on the strategic level. In the basic design, each decision level consists of six decision dichotomies representing 12 choices. The choices emanate out from a central core having the shape of a hexagon. The hexagonal cores are regions where criteria are used to decide which choices are to be selected in considering the dichotomies. The nature of the criteria depends on the level that is being accessed and the decision that is being made.

In the strategic level, the range of decisions revolves around whether the organization is thinking toward the long term or is short term in its orientation; whether the organization is aggressively attacking its markets or for a time is defensive in its strategy; whether it is orienting more toward technology push or to marketing (needs) pull; whether it is willing to seek out high risk situations or is operating conservatively; and whether it needs to develop opportunities using internal resources or should be purchasing and licensing technologies from outside sources. Generally speaking, it is considered important in any level to have a mechanism for either gathering more information or moving to an explicit decision.

Table I.2. Selection or Decision Criteria for the Strategic Level (A)

<i>Information Gathering vs. Deciding (I)</i>	<i>Long Term vs. Short Term Horizon(II)</i>
1. Availability of more information	1. Performance to date and projected
2. Level of environmental stability	2. Organizational cultural orientation
3. Confidence in projections and forecasts	3. Influence of stakeholders
4. Environmental imperatives operating	4. Predilections of Chief Executive Officer
5. Advantages of proaction vs. inaction	5. Willingness to change
<i>Internal Focus vs. External Focus (VI)</i>	<i>Offensive vs. Defensive Strategy (III)</i>
1. Capabilities for internal development	1. Cultural set
2. Availability of external technologies	2. Internal strengths and weaknesses
3. Funding availability	3. Environmental opportunities and threats
4. Costs-benefits of partnering / alliances	4. Prior "track-record"
5. Competitive needs	5. Sustainability
<i>Risk-embracing vs. Risk-avoiding Posture (V)</i>	<i>Technology Push vs. Marketing Pull (IV)</i>
1. Current root strategy and need for change	1. Prior history and levels of success
2. Risk / benefit analysis outcomes	2. Capability for pioneering technologies
3. Capital available	3. Influence of buyers (customers)
4. Compatibility with key players	4. Consistency with technology policy
5. Sustainability of risk posture	5. Anticipated effect on performance

In order to understand how to use the model, it is helpful to focus on the center of Figure I.5 where an ellipse is positioned. The decision maker simply "moves" around this ellipse until it is determined which of the six basic dichotomies is to be accessed. The pertinent criteria of Table I.2 are then considered and a decision is rendered. The most appropriate operating mode is then selected. That operating mode remains in focus until another decision becomes important.

The model allows the decision maker to enter whichever decision mode is considered appropriate at any given point in time and in any sequence or reiteration that is deemed desirable. The decision maker can also exit to another level and consider other decisions that are considered pertinent. The choices given in the model are not intended to be static in nature. They are contingent choices that can be made and then shifted readily in response to new criteria, or they can be held long term. In that sense, they are not entirely mutually exclusive; yet at any given moment, it is assumed that certain choices will be emphasized over others (much like a person being multilingual but speaking in one language at a time). The choices operating can also vary from one part of an organization to another and may vary even within the same part of an organization at different points in time. The model that has evolved is intended to be dynamic, that is, to provide mechanisms for shifting from one operating mode to another, and back and forth as desirable, consistent with contingent criteria.

Behavioral Level Decision Dichotomies (Creativity Management) (Level B). At the behavioral level, the creativity management level, decisions impact directly and immediately on the technical professionals who should strongly participate in the elections that are made. These decisions determine the nature of operating environments at the individual level at any point in time (Figure I.6). This level is particularly important because it is the region of greatest emphasis on creativity. It is the region of discovery and invention, the region of technical and scientific breakthroughs. Here, ideas for important new products and processes are formulated, and they are also translated into meaningful prototypes. Here, issues in management are concerned with how do we best promote creativity while also being concerned with managing verification of new ideas. It is perhaps the most dynamic region, one involving frequent shifts of emphasis and structure. It is the domain of the individual; yet the individual must also work effectively and cooperatively in groups in order to benefit from such interactions.

The willingness to allow autonomy in decision making, along with structure in requiring accountability, is one of several premises which have been identified as important in the management of creativity. Accordingly, management models aiming to promote creative performance must allow participants (managers and inventors) to make appropriate choices depending upon the criteria.

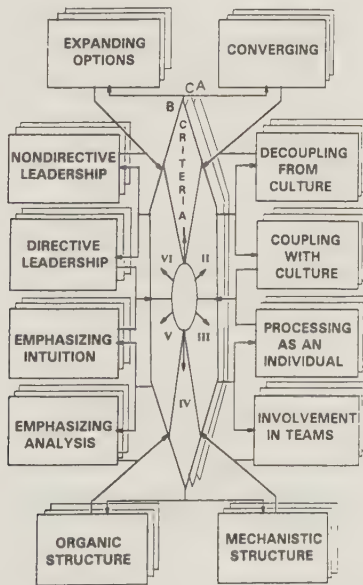


Figure I.6. Integrated Model for Decisional Dichotomies at the Behavioral (Creativity Management) Level

Flexibility and opportunities to choose are preeminent in importance, and are considered necessary for innovation as long as structure and "unstructure" are included among the relevant contingencies. One role evolving for management then becomes the ability to select appropriate environments and/or to allow the inventor to select operating environments that are appropriate considering the situation and the needs of the people involved.

The decisions in the behavioral level of the model represent matters of special concern to the creative professional. In this region, we are dealing mostly with perspectives and choices of individual inventors who are striving to create new products, new processes, new technology, and/or new science. This is identified as the "micro" domain. The key choices in this region include: whether the individual should continue gathering information or should decide and move toward closure; whether the individual should closely link with the operating culture or should decouple from that culture in order to access to non-traditional, even radical, approaches; whether the

*Table I.3. Selection Criteria for Behavioral
(Creativity Management) Level Dichotomies (B Level)*

<i>Expanding Options vs. Converging (I)</i>	<i>Decoupling from Culture vs. Coupling with Culture (II)</i>
1. Needing to decide (Imperatives for action)	1. Favorableness of cultural situation
2. Performance to date	2. Reliability of pertinent individuals
3. Flexibility of schedule	3. Track-record of organization
4. Likelihood of success in implementation	4. Performance of individuals on project
5. Feasibility of project	5. Level of urgency
<i>Nondirective vs. Directive Leadership (VI)</i>	<i>Processing as an Individual vs. Team Involvement (III)</i>
1. Preferred leadership style	1. Individual preferences vs. performance
2. Desire for participation	2. Quality of team activity/performance
3. Need for direction	3. Relative influence in gaining support
4. Characteristics of the situation	4. Locus of knowledge base
5. Performance on the project	5. Nature of organizational culture
<i>Emphasizing Intuition vs. Using Analysis (V)</i>	<i>Organic vs. Mechanistic Structure (IV)</i>
1. Experience of key players.	1. Need for structure in environment
2. Level of project success	2. Preferences of individuals and groups
3. Track-record of key players	3. Stage of creative process
4. Cultural preferences	4. Performance on the project
5. Prior operating mode	5. Influences from external environment

individual should operate *as an individual* (making individually-oriented decisions) or should function in groups or teams; whether the individual should operate in an organic (initiating) subenvironment or in a mechanistic (implementing) subenvironment; whether the individual should be emphasizing intuition or should be primarily analytical in problem solving; and whether the leadership operating should be nondirective or directive in nature.

Upon entering the core of the Behavioral Level (Figure I.6), the decision maker selects one of the six decision dichotomies and then considers pertinent criteria as given in Table I.3. For example, in determining whether individuals should process primarily as individuals or operate mainly in groups, one reviews such criteria as the individual's preferences versus performance, the quality of team activity and performance, the individual's relative influence in gaining support, the locus of the knowledge base, and the nature (and predilections) of the organizational culture. The decision maker then selects the individual or group mode depending on the situational context and the tested criteria. If the individual mode is selected, emphasis is placed on self-motivation and singular effort—in contrast to the group mode where peer pressures and mutual support systems are prevalent. The individual or the group mode is then operationalized. In so doing, there is a mechanism for imparting needed variety into the environment of creative individuals.

In considering individualism and management, perhaps one of the most important contingencies to recognize is the need for individuals to self-actualize during the creative process (Maslow, 1970). It is also recognized that, under constraints of time, groups can tend to adopt pedestrian approaches and to pursue these with persistence and solidarity even though they may not provide needed solutions (Janis, 1982). Accordingly, there may be a singular requirement in projects to allow mechanisms for decoupling from group consensus and the operating culture of an organization. Such decoupling may be especially important when the goal is to derive technologically-based products that are radical departures from earlier models.

As before, the model allows the decision maker to enter whichever decision mode is considered appropriate. Exiting the behavioral level, or not, represents a global decision on whether to focus on creativity management as a key priority.

Decisions made in the micro domain are also considered changeable and dynamic, depending on contingencies. Not only does the environment of the individual change, but the reactions of the individual to the environment also change depending on personality, circumstances, and time. In a sense, freedom or autonomy can become a frame of mind.

For each of the levels operating, the choices are made by considering various criteria. Choices may be operating concurrently but, at any given

point in time, it is likely that one particular set of options will be operating in sharper focus than will another set of options. The nuances relating to some of these decisions will be further elaborated in relevant portions of this text.

Functional Level Dichotomies (Level C). Decisions made at the functional level determine the nature of interactions at the group level and therefore influence the ability of the organization to implement and translate new developments into practice. So again, the environment of the technical professional is strongly influenced by these decisions.

The functional level dichotomies are arrayed in Figure I.7. Decisions at the functional level involve issues relating to the interactions among various functional elements or subsystems within and outside of the firm. Cross-cultural teams are included in this level. Since the mode of operation is largely, though not exclusively, implementational, this is the region of technology transfer. Here we are concerned with decisions of: whether problems relating to functional or project team interfaces should be resolved or should additional information be gathered; whether venture projects should be managed bottom-up or top-down; whether manufacturing should adapt to the initiatives and directives of the design function or should the design function operate by accommodating to the requisites of manufacturing; whether cross-functional teams should be generally

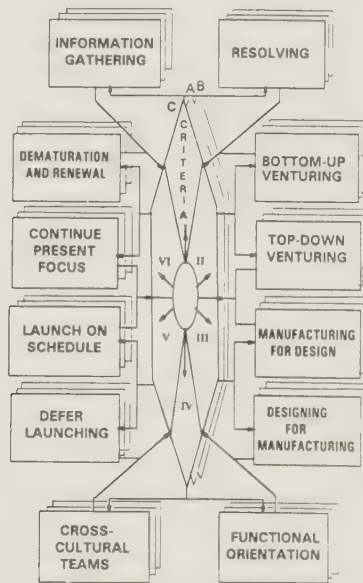


Figure I.7. Integrated Model for Decisional Dichotomies at the Functional Level

operating or should the orientation be primarily functional; whether the decision should be to defer launching the new technology or should the launch be as scheduled; and finally whether effort should be renewed toward new development cycles or should the focus continue on present programs.

Table I.4 provides core criteria which may be used in rendering choices at the functional level. The decisions made in the functional region of the innovation process have an immediate impact on the ability to achieve successful scale-ups in commercialization or implementation of new technologies. In a very real sense, the quality of the "end-game" for each innovation depends on how well the various functions interact in bringing new developments to fruition. Products and processes "live or die" depending on the ability to effectively navigate through the interfunctional interfaces.

To this point, we have presented an introduction to the decisions that are considered important in achieving successful innovations. Further elaborations will be provided throughout the ensuing chapters and case studies.

Implications. The literature and its embodiment in the proposed decision models suggest some interesting implications for practitioners and managers. One implication is that individuals engaged in creating new technologies

Table I.4. Selection Criteria for Functional Level Dichotomies (Level C)

<i>Information Gathering vs. Resolution (I)</i>		<i>Bottom-up vs. Top-down Venturing (II)</i>	
1. Level of ambiguity		1. Locus of expertise and knowledge	
2. Extent of dysfunctionality		2. Desirability of intrapreneurship	
3. Anticipated impact of interventions		3. Willingness to delegate and empower	
4. Nature of operating culture		4. Need for speed in decision-making	
5. Need for change		5. Compatibility with culture	
<i>Renewal vs. Present Focus (VI)</i>		<i>Design for Manufacturing vs. Manufacturing for Design (III)</i>	
1. Availability of slack resources		1. Radicalness of technology	
2. Level of control of operating environments		2. Ability to transfer technology	
3. Funding capability		3. Political ecology (climate)	
4. Availability of new ideas, new discoveries		4. Ability to apply concurrent engineering	
5. Imperatives for action		5. Imperatives for action	
<i>Launching as Scheduled vs Deferring (V)</i>		<i>Cross-Cultural vs. Functional Groups (IV)</i>	
1. Performance in field trials		1. Rate of knowledge growth	
2. Interest shown by lead users		2. Need for interfunctional communications	
3. Quality of scale-up		3. Duration of time in project teams	
4. Achievement of design parameters		4. Organizational culture	
5. Commitment by top managers		5. Performance in and out of teams	

are very frequently operating at fulcrums of dichotomies. It would therefore be important for organizations to provide environments which encourage choice and the flexibility that goes along with that posture. It is also assumed that creative individuals are best served by having opportunities to function with a variety of experiences and environments in contrast to having more singular or monolithic environments. Given that requirement, managers should be open to introducing a variety of experiences or contingencies such that individuals receive, and can opt for, structure or “unstructure” as deemed appropriate. Such approaches as these would help managers of innovation to move away from singular approaches which seem to be unproductive or inoperative in the long term. The design also allows creative practitioners to feel comfortable, not only with loose structuring but to understand and accept the necessity that structure, goal-directedness, and accountability are also appropriate and are theoretically justified contingencies in the management of creativity. By offering a greater understanding of dichotomous thinking especially in the creative process, portions of the proposed decision model may also prove useful, and are presently under further study, as the basis for an evolving knowledge-based system (Ongwisesphaiboon et al., 1990).

INSIGHTS FROM LEADERS OF TECHNOLOGICAL INNOVATION

General Approach

In conducting the research leading to this text, interviews were held with noteworthy individuals who have achieved levels of excellence in some field of technological innovation. A wide spectrum of individuals were tapped, ranging from senior “superstars” to more junior members in earlier stages of their careers. These individuals operated as managers or practitioners and frequently both managed and practiced the creation of new products or new technologies. They represent broad constituencies, coming from industry, government, and university sectors. While their position titles were diverse, for example, ranging from chairman of the board to CEO to vice president of R&D to research manager to professor to engineer or chemist, they all possessed important insights into the “real world” and were genuinely interested in achieving technological innovation or in contributing substantially to scientific knowledge. Backgrounds of the interviewees are threaded within the various texts of the interviews or, additionally, may be found in the Biographical Supplement section at the back of this work.

In conducting the interviews, each individual was asked to describe elements that promote technical creativity and innovation. These were

called “facilitators.” They were also asked to describe those elements (“barriers”) which impede the process. Their thoughts, which support the nature of the developed models, are introduced at various points in this text. The interview method is an effective instrument for gaining insights into areas of science, technology, invention, and innovation (Bass, 1994; Brown, 1988).

Interview with Robert W. Galvin, Chairman of the Board of Motorola, Inc.

Interviewer: Mr. Galvin, you have led the development of communications technologies and have established an incredibly successful, multibillion dollar enterprise which continues to grow. Much of that success has stemmed from proprietary technical advances which were then commercialized on a world-wide basis. Can you tell me what, in your view, facilitates technical creativity? What helps firms to be successful in managing technological innovation?

Mr. Galvin: First of all, it is important that a manager should have respect for creative professionals and their loyalty to their professions. They should have opportunities to associate with other professionals and peers at technical meetings. But, that association represents only one dimension, albeit an important dimension. Engineers also need to be exposed to various parts of the business and especially to customers. They need to have direct contact with various “publics” in order to be better able to pursue areas which have some potential for our business. That requires contact with customers. In that regard, engineers need to be “team players.”

Along with the exposure to customers, engineers also need to have some “significant say” in what assignments they will pursue and in what methods they will use. In other words, the engineers need to have “some perceived increment of control of their destiny.”

Engineers also need to have a road map, a structure, that is, a formal means for extrapolating to where we are going. The structure gives a plan for achieving.

It is also important that managers and engineers be willing to *listen* to one another and to relevant constituencies both inside and outside of our company.

There needs to be an environment of some consistency and predictability, so that *resources* are available to see

the project through to successful completion. Individuals also need to receive *recognition*. Recognition can come in a variety of forms, for example, as “thank yous,” or bonuses, or simply by giving attention to what they are doing.

Teaching and learning are very important. Individuals should be exposed to “academics” who create or synthesize new ways of being effective, new ways of doing things better. Engineers need to consistently expand their horizons on how to design better for manufacturability, so that evolving products can be manufactured in less time. At Motorola, we are interested in “cycle time management,” that is, to be able to efficiently manage all aspects of our business.

Interviewer: It sounds like you feel that having a structured plan and accessing to customers are very important.

Mr. Galvin: Yes, I personally went to customers and found out what was needed. I rediscovered some basic realities about the importance of input from customers. And I, along with others, conceived and designed a “road map system” and helped get it going at Motorola. At the time, I was dissatisfied. I felt that various technology segments were not moving consistently, were not goal oriented. Actually, we seemed to be evolutionary in nature or response. To correct this, we synthesized the “technology road map” by looking at various components which were available. We realized that we had to become “smarter” and so we went to universities like IIT (Illinois Institute of Technology) and developed some courses.

I also considered the realm of productivity in creative thinking and recognized that only a relative minority of ideas are thought of that reach fruition. In order to be more successful, ideas need to have a critical connection, a stimulation of sorts. One can think of it as a “trigger” or a “jump-starter.” In order to understand the process better, I personally went through the practice of doing creative thinking in preparation for the potential for thinking of an idea. For example, I reflected that we needed a certain technology and then wrote down some ideas without criticism. I went out looking for other ideas and talked to various engineers. Finally, in the aggregate, I found out what we were doing, sort of by

“managing by walking around.” I recognized, perhaps because of my impatience, that we needed a system. The system that evolved, the trigger, is what we now refer to as “the Technology Road Map.”

Interviewer: I’d like to “switch gears” at this point and ask your view of what elements get in the way? What interferes with technological creativity? What are some significant barriers?

Mr. Galvin: Perhaps over-management is the strongest barrier. Over the long haul, if a boss bosses too much, one gets frustrated. Managers need to be sensitive to this negative aspect and need to avoid it.

Secondly, some engineers don’t know that they are being inhibited by not knowing (what is going on), by not having access to customers. So when communications with customers are inadequate, that becomes a serious barrier.

Inconsistent allocation of resources represents another barrier. This arises when professionals have to do excessive routine work. That becomes frustrating and inhibiting. And, of course, when there is a lack of any of the positive stimuli we mentioned earlier, that lack becomes a barrier to creativity.

Interview with Cynthia M. Friend, Professor of Chemistry, Harvard University

Professor Friend: In order to promote technical creativity, I think it is important to *not stay in a “rut.”* One needs to see new connections in doing Ph.D. level research. It is desirable to have new people coming in at frequent intervals. So inflows of individuals are desirable. It is sometimes important to get away and, for example, attend scientific meetings. Persistent routines should be avoided. Otherwise, people tend to get stuck.

But, it is also important to be *productive*, to have an idea and to follow through on it.

Healthy *disagreements* are also helpful. I like to see people strongly advocating their points of view in an atmosphere that is somewhat adversarial. Interestingly, the best students seem to be those who are somewhat disrespectful, who don’t just argue but question their advisers. So, I think it is important not to be passive.

Creativity is *impeded when there is too much rigid direction*. Some direction is, of course, necessary in order to stay in the funding context. But, beyond that, people should not be too narrowly channeled. Research is also slowed when facilities are not provided. It seems to me that barriers always have a negative impact on performance. Some people just don't respond to facilitators.

In considering *specific projects*, a particularly successful one involved catalysis of alkene oxidation. The researcher found and identified a new, specific structure with oxygen on the iridium catalyst surface. It was very unexpected. We were not looking for it. So, this was an example of serendipity. The discovery has led to a whole series of publications. The work was done very recently. The student just successfully defended his work and received his Ph.D. degree. I was his adviser. This work came to mind because it was brand new. There was luck. We were open to an opportunity when it arose. We opened up a whole new area for research. That's very satisfying.

On the unsuccessful side, I can think of a project which involved an effort to build new advanced instrumentation. We were trying about eight years ago to build a scanning, tunnelling microscope. (It is now available commercially.) It is very common to build instruments as part of research programs. We wanted to use the microscope to see individual metal atoms on the surface. Unfortunately, our instrument was very sensitive to vibrations. We had to abandon it. The student involved went on to another research project. So, it became evident that there were technical barriers which could not be overcome. We tried to take too big a leap (in technology). And we did not have the engineering skills required for accomplishing it. So, it was a learning experience.

MINICASES

Introduction

In order to enhance our understanding of the dynamics of managing creativity and innovation, a series of experiential "minicases" are included

this text (Ginn, 1985). The minicases were selected from a larger anthology of scenarios and experiences that have been collected over a long period of time. They represent the essence of real world situations but have been disguised so they are referred to as “simulations.” The simulations reflect aspects of theory as well as practical issues in the field of innovation. Scenarios are described, then followed by short discussions to illustrate some plausible approaches in developing solutions.

A variety of cases are given below to introduce the method. In subsequent chapters, the minicases employed are more closely related to the specific subject matter that is being developed.

***Minicase I.1. Complete Operating Plan (1 & 5 Years)
Needed in Three Weeks (“You Can Do It!”)***

Scenario. You are a functional vice president of a medium sized company which is a division of a large corporation. Your areas of responsibility have included R&D and manufacturing. One day, the division president calls an executive meeting and says the corporate CEO has asked all divisions (for the first time) to develop and submit their operating plans. The memo was late in coming over so by now only three to four weeks remain before it is due. The other vice presidents at the meeting say it is impossible to do it in that short a time. You feel likewise. But, the division president likes your communications style and asks (tells) you to do it, saying: “You can do it; I know you can do it!” You know you can’t do it alone and you have power only over your areas of responsibility. What do you do? (WDYD?)

Discussion. Two issues are confronting the vice president of R&D and manufacturing: A risk/benefit assessment for accepting or rejecting the assignment (Can or should one say “no” to the CEO?) and how to influence other vice presidents over whom he holds no position of authority? If it is assumed that the opportunity is large in relation to the level of personal risk, then the vice president needs to address the issue of how to ensure getting the needed cooperation from the other vice presidents. Such cooperation would be essential, given the extremely short deadline, and the need for the vice president to serve as a “managing editor” in assembling the documents. One way of gaining the cooperation would be to establish a “psychological contract” in real-time while accepting the assignment. In such a case, the vice president would accept at the meeting with a statement something like: “I am happy to accept but that acceptance would have to assume the *total* cooperation of everyone in this room. Without that cooperation, the job would be impossible to accomplish.”

Minicase I.2. "The Great Foam-Out"

Scenario. You are the R&D director for a consumer products firm. You receive a call from the director of marketing Friday at noon. He is very agitated and angry. He informs you that aerosol cans containing a new foaming cleaner, which was developed in a "rush project," are leaking, so that cartons and racks in the warehouse have froth trickling down the outside. Not all the cartons are leaking, but he doesn't know how many of the cartons are good. A large shipment of the product was being readied to fill an order for a major chain of grocery stores. The order was to be shipped that day. The marketing director just happened to go to the warehouse. The marketing director, who is well-connected to the CEO of the firm, yells over the phone: "It must be shipped on time; but it must be good product!"—then hangs up. WDYD?

Discussion. The director of R&D of any organization is commonly positioned at the center of a field where key decisions have to be made. Considerable judgment and expertise have to be exercised. As in any decision process, avoiding a decision is, in a sense, a decision that others are to decide. If the R&D director recommends shipment of part of the material, and the decision turns out to be wrong, no one will remember that the R&D director was simply trying to be cooperative. One cannot escape responsibility. In this case, the R&D director must deal with decision making in the face of uncertainty. Uncertainty exists because it is normally impossible within a few hour's time to fully establish the limits of a problem with complete reliability. The question is: How much risk is one willing to assume in incurring a product liability problem in order to try to satisfy a key customer? Some will argue that the R&D director should do the "right thing" and stop shipment until the problem is completely defined. More likely than not, all players will likely agree to defer by late afternoon.

Minicase I.3. Overinstructive Boss

Scenario. You have joined a new department as a design engineer in product development and are now responsible for developing new formulations. You have two technicians reporting to you, and you in turn report to a section manager. You think of yourself as creative and hardworking. Generally, you arrive at work early. You leave after everyone is gone, and only after you feel everything is done that should be done. You like to plan your own work and generally accomplish more output than your peers. Your new supervisor is strictly "Theory X." He assigns written protocols or instructions detailing work assignments each day. You find these on your desk every morning and get very irritated. WDYD?

Discussion. This case involves a conflict between two distinctly different orientations, a mechanistic approach utilized by the supervisor, and an organic orientation favored by the design engineer. Formal structures are employed by the supervisor while the engineer prefers unstructured approaches. The “Theory X”-oriented supervisor assumes that strong, detailed direction is needed to ensure a high level of effort. The “Theory Y”-oriented engineer is highly self-motivated and is professional in his approach to work. At issue in this case is whether or how the design engineer should confront the supervisor, and whether the supervisor can change his operating style in any event. Styles of management can become monolithic and ingrained when they are utilized over long periods of time. They can become institutionalized if some credible level of success is achieved even though they may not be entirely appropriate when new situations are encountered.

Minicase I.4. Potential Short-Fall in an Ad Hoc Group

Scenario. You are the project leader of an ad hoc group which was formed to develop a new product within a very short time frame. The team was formed by your boss without prior consultation and includes members from groups and departments different from your own. In order to achieve the stated objectives, each team member must deliver results in his or her specialty at a certain time and with a high level of quality. At least two members of the group seem to be “hanging back,” and perhaps waiting for you to fail. You have no formal authority, yet you need to get the work done and time is running short. You do not want to fail, yet you do not want to go to higher management. And even the boss seems uncomfortable with your new responsibility. WDYD?

Discussion. Innovators frequently have to establish power bases through mechanisms that are not derived from position authority. That is a challenge which is commonly encountered by project leaders who are managing *ad hoc* teams. In this case, the project leader is limited in options because of an unfavorable political environment. However, power can be gained and structure can be introduced by drawing upon peer authority as an operating mechanism. That can be done by establishing targets and milestones and calling upon individuals to report progress in formal group meetings.

Minicase I.5. Bacteria in the Product

Scenario. A report from sales indicates a product is smelly, and it is separating in the bottle. You are the CEO. You call your department managers to find out how this could have happened and how it can be

corrected. Manufacturing says: "It's a defective formula. Not enough preservative was put in, and marketing rushed us." R&D says: "The plant messed up—dirty housekeeping. Have you been in the plant lately? It's unbelievable. And marketing rushed us." Marketing says: "R&D and manufacturing said it was Okay to go ahead with production and sales." Everyone is sensitive. You are the CEO. You have key customers insisting on an immediate solution. WDYD?

Discussion. In addition to the serious, immediate problem of product quality that must be addressed, there is a very negative atmosphere in this organization—one of severe blame-placing and conflict. The product problem has to be investigated in an objective fashion so the cause can be identified and appropriate measures taken to avoid a recurrence. But the climate problem is more systemic and deserves continuing attention. The role of the CEO in permitting such a negative atmosphere justifies pervasive analysis, since the CEO is ultimately responsible for the organizational culture. The CEO sets the "tone" of the organization and that tone generally becomes very apparent when the firm is stressed during programs of innovation. The CEO needs to confront this significant problem as well as the more immediate symptoms.

NOTES

1. In Figure 2, the term "Creativity Management" is given as the heading for the micro-domain because creativity is most concentrated in that domain which includes the activities of product development and invention. It should be understood, however, that creativity occurs in *all* stages of the innovation process.
2. Outputs in innovation (Figure 3) include commercial developments and/or technical developments having little or no direct commercial value but which are important in terms of societal benefit or benefit to the scientific community.
3. Human Relations theorists favor Theory Y assumptions which argue that individuals have a fundamental desire to work and be creative and productive (Figure 4).
4. Fayol's (1946) 14 Principles encompass: division of labor, delegation of authority, maintenance of discipline, unity of command, unity of direction, subordination of individual interests to organizational goals, appropriate remuneration, centralization, scalar communications, order, fairness, a stable environment, encouragement of initiative, and unity of effort.
5. It is also acknowledged that an overemphasis on bureaucratic rules can lead to frustration.
6. Theory Y assumes that the average human being is creative, feels that work is natural and is internally motivated to achieve objectives to which there is commitment (McGregor, 1960). The level of commitment depends upon the rewards that are associated with the achievement.
7. In Maslow's (1970) hierarchy of needs, self-actualization is similar to self-fulfillment, that is, realizing the opportunity to be whatever one can be. Esteem needs encompass desires for achievement and prestige. Maslow's focus is strongly targeted on the individual and what motivates him or her.

8. McClelland (1961) also ranks achievement over power and affiliation, and Alderfer (1972) considers the need for personal growth higher in rank than social relations and existence needs, in providing similar perspectives on motivation.

9. *Organic* systems of management are those in which: employees can contribute to shared tasks, the tasks are adjustable, there are relatively few rules and less hierarchy, communications are free-ranging, and knowledge and control of tasks can be located anywhere in the organization. *Mechanistic* forms are those in which: tasks are specialized and rigidly defined, there is a strict hierarchy with many rules, vertical communications are the norm, and knowledge and controls are concentrated at the top of the organization (Burns & Stalker, [1961]1971; Meadows, 1980a, 1980b).

10. According to Peters and Waterman (1982), companies that have achieved excellence have eight attributes which contribute substantially to their high levels of performance. The eighth attribute, "simultaneous loose-tight properties" (p. 15) allows for the possibility of contingent structuring within organizations.

11. The decisional dichotomies in Table 1 represent many of the fundamental decisions that are pertinent in the process of technological innovation. The subordinate choices may not be all-inclusive and are intended as "umbrella terms" covering many of the issues that are developed in subsequent chapters. It is possible, depending on the nature of the activity, that additional choices or even additional levels might have to be added. The subsystems nature of the integrated model makes the model readily expandable for supporting such additions.

12. Venturing is placed in the functional or interfunctional level, rather than in the strategic level, because of the emphasis placed on technology transfer issues in the discussion.

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Chapter II

Competitiveness and Commitment to Innovation

In order to be successful in making creative advances in science or technology, it is very important to have the necessary tools.

—Sharon R. Long, Stanford University

Companies, in general, will do less basic research, and will tie more money to business related programs than was the case in the past.

—Walter L. Robb, General Electric R&D Center

ECONOMIC CONSIDERATIONS AND INNOVATION

The classical definition of innovation, as underpinning capitalism, is attributed to Schumpeter (1939, pp. 87, 91, 102; Fels, 1964).¹ Schumpeter regarded innovation as any systemic changes in delivering products (commodities) to the consumer. The changes could include changes in methodologies, in organization, in technologies, in design, in processing techniques, and so on, as long as they impacted on the delivery of products. Schumpeter (1939, p. 87) defined innovation simply as “the setting up of a new production function” and included situations in which factors are combined in a new way. Innovations must be significant to qualify for inclusion in the Schumpeterian scheme of things. Innovations not only involve new technologies and methods, they also require that new individuals or new perspectives enter into the picture in some way. Emerging innovations tend to be clustered and, if promising, are frequently copied by others with new modifications. Discontinuities are common.

The challenge presented by an innovation strategy, once adopted, is that organizations must continue to innovate to avoid being overtaken by inevitable rivals (Lawrence & Dyer, 1983; Peters, 1987, 1990; Levitt, 1988). New generations of technologies and products must be developed. Otherwise, they become vulnerable to substitutions and decline. The commitment must persist. It goes with the “territory.”

Within the Schumpeterian framework, individuals who carry out the innovations are the entrepreneurs. The entrepreneur may be the leader of the firm or the inventor or anyone who assumes the necessary risks. Profits from such endeavors may be realized, or not, depending on convergence with other factors. The entrepreneur “leads the means of production into new channels” (Schumpeter, 1961, p. 89). The implications from these postulates are that growth and decline stages of business cycles are influenced to a substantial degree by trends of innovation. Indeed, Clemence and Doody (1950, p.73) stated that “business cycles, then, are identical with the capitalist process of which the driving force is innovation.” Successful innovations expand production, lead to new varieties of production, and promote growth phases of an economy. The strong growth of employment in the United States during the 1980s may be attributable, at least in part, to the introduction of new information technologies as microprocessor applications proliferated. That period of growth was followed by a recession. Innovative growth is fragile. Markets can become saturated and consumer demand can soften. Many factors influence the degree to which innovation and growth are stimulated within an economy. Those factors include political, social, and competitive influences operating at domestic and international levels. The situation is highly complex. Yet, intuitively, it is understood that growth is triggered by innovation.

The above discussion relates primarily to “macro” issues. If we consider issues that are more “micro” in scope, positive impacts from innovation are clearly evident. At the company or industry level, one can clearly identify turnarounds in performance that have resulted from innovation. There are myriad examples, such as, in the steel industry, where development of the continuous production of sheet steel has shifted performance to more favorable levels. Cellular technology has infused the telecommunications industry with renewed growth, as has fiber optics technology. Interactive television and the information superhighway should favorably impact many industries. Although bio-engineering is a controversial area, one can also anticipate stimulation of relatively static industries from the introduction of genetically engineered products having enhanced properties.

Inventions, Innovation, and Economic Growth

It is relevant to consider how technology has evolved. Table II.1 lists some significant inventions and scientific advances that occurred during the eighteenth, nineteenth, and twentieth centuries (Vagtborg, 1976; Hawke, 1988; Diebold, 1990). The level of sophistication for new discoveries has

Table II.1. Evolution of Some Technologies and Products (18th-20th centuries)

<i>Period</i>	<i>Technology or Product</i>
1700s	American Axe, Woodburning Stove, American Plow, Storm Windows, Kite-Lightning Experiment, ⁴ Dumbwaiter, Pedometer/Odometer, Steamboat, Cotton Gin, Interchangeable Parts
1800s	Steam-driven Textile Weaving, Locomotives (Railroads), Otis Elevator, Telegraphy, Sewing Machine, Typewriter, Steelmaking (Bessemer Furnace), Steel Plow, Harvester, Chemical Derivatives, Vacuum Tube Amplification, Radio/Wireless Communication, Motion Pictures, Telephone, Phonograph, Electric Light, Alternating Current, Petroleum Derivatives, Popular Camera, Steel-framed Building, Automobile, X-rays, Radioactive Elements, Seismograph, Gasoline, Automatic Bottle-making
1900s	Airplane, Tractor, Sound Movies, Digital Computer, Television, Polymers/Plastics (Nylon), Penicillin, Radar (Microwave Energy), Heavy Water, Nuclear Energy, Jet Aircraft, Advanced Rocket Fuels, Magnetic Recording, Transistors/Semiconductors, Laser Technology, Solar Energy Technology, Membrane Technology, Spiral Helix/DNA Cloning, Enzyme Technology, Ceramics (Materials Science), Sputnik, Apollo Space Vehicle, Freeze-drying, CAT Scanners, Magnetic Resonance Imaging, Microprocessors, Personal Computers, Computer Software, Fiber Optics, CAD/CAM/CIM, ISDN (Integrated Services Digital Network), Cellular Phones, Bioengineering, HDTV, Superconductive Materials, Electronic Highways, Virtual Reality, Nanotechnology

Sources: Partly derived from Vatborg (1976), Hawke (1988), and Diebold (1990).

continued to advance with little interruption during this period of time. The progression is most impressive. The number of radical inventions that produce fundamental change, that is, create whole new ways of doing things, also seems on the rise. Clearly, all that can be invented has not yet been invented and, hopefully, that will never be the case.

The linkage between inventions, innovation, and economic growth has been strongly articulated by Schmookler (1966) and Parker (1978). In contrast to Schumpeter's approach, Parker (1978, p. 26) regards invention and innovation to be inseparably intertwined. The terms are distinguishable in meaning, but they are not separable. Since inventions involve developments which are potentially patentable, this interpretation also links the importance of patents and patenting with innovation.

Economic forces also connect invention with innovation. Schmookler (1966, pp. 26, 46) has shown that there is a strong positive relationship between the demand for products of an industry and the numbers of patents issuing in a particular field. To a significant extent, inventors seek to become

entrepreneurs or intrapreneurs, and they tend to focus their inventive abilities in areas that are likely to result in economic benefit. So inventions stimulate economic activity, and economic activity and investment stimulate more invention. Inventions, innovations, and the consequent economic growth tend to occur in clusters during certain time periods, followed by slower periods of “technological stalemates” (Gomulka, 1990, p. 30). Inventive capacity increased, overall, for more than 200 years during the industrial era.

The work of Mansfield (1971) suggests that the U.S. economy is strongly supported and shaped by the nature of technological change that has evolved. Economic growth is largely attributed to the stimuli that proliferate from technological change. In modern times, technological changes and their embodiments in new products and processes, are increasingly based on new science, that is, on advancing technical knowledge. The nature of inventive activity shifted during the twentieth century. Prior to the twentieth century, inventions were largely (though not exclusively) based on empiricism and mechanics (Gomulka, 1990). More recently, inventions have derived from a greater emphasis on science-based technologies. Such fields as chemistry, biotechnology, physics, and electrical engineering have contributed vastly to the activity of inventing. These are fields in which highly-trained, technical professionals are operating. The shift to science-based invention has required that inventors have sufficient mastery of their fields to be able to move to the “cutting edge” and then make significant contributions. At the same time that they possess a mastery of a scientific discipline, inventors must also have the necessary creative skills to derive new combinations, new concepts, and new syntheses. Frequently, they also need to have mechanical capabilities, or be able to access such capabilities. Even with scientific knowledge and expertise, it is common that accidental or serendipitous discoveries continue to occur and be eminently important. Such discoveries do not weaken our argument since they generally result from intense, knowledge-based inquiry, and require astute professional understanding of the opportunities that are created.

Competitiveness, Productivity, and Technological Innovation

Concerns about the competitiveness and productivity performance of the United States have been growing during the 1980s and into the 1990s. The frame of reference has centered on Japan in particular since Japan enjoyed a period of spectacular growth in productivity during that period. The slower rate of growth in the United States has been well documented (Baily & Chakrabarti, 1988; Competitiveness Policy Council, 1992). Concerns have arisen because a lower rate of growth inevitably would have an adverse impact on the relative standard of living that would be enjoyed at some point in time.

Productivity is intimately linked with technology, innovation, and market forces (Baumol & McLennan, 1985, p. 3). According to Baily and Chakrabarti (1988, p. 1), output per labor hour “grew 3.3 percent a year between 1948 and 1965 but slumped to 1.4 percent a year between 1965 and 1985.” The decline in productivity growth occurred to a significant extent because available opportunities were not fully exploited. While the United States retained its economic leadership in certain areas, it was widely argued that the United States had been in a state of decline and was losing competitive strength in its base of technology and industrial science (National Science Board, 1992). The study by the National Science Board (NSB) underscored the fact that “the U.S. share of several technology markets eroded during the 1970s and 1980s” (p. 30). For example, major contractions of U.S. company shares of domestic markets were observed for the consumer electronics industry as foreign companies achieved substantial inroads. The genesis of new industries evolves from pioneering research in the private sector, or in research universities, or in government research facilities. Such institutions have been experiencing stress in their economic environments. To meet competitive challenges, more and better spending in support of R&D was recommended, along with the setting forth of more favorable policies by corporate and federal constituencies to promote needed advances in technology. Baumol and McLennan (1985, p. 198) also concluded that R&D should be strengthened.

Investment in Technological Innovation: R&D Funding

In absolute terms, the United States spends more on R&D than any other country. The study conducted by the National Science Board (NSB) of the National Science Foundation (NSF) showed that non-defense R&D expenditures in the United States totaled \$94.1 billion in 1990 (NSB, 1992, p. 74). That impressive figure far exceeded the expenditure of \$58.8 billion in Japan and \$27.3 billion in Germany. However, the comparison became less favorable when figures for R&D investment were considered in relation to GDP (Table 2). The United States, at 1.9 percent of GDP for R&D expenditures, remained substantially below the levels reported for Germany and Japan in 1990, and reflected a fairly flat situation from 1971 to 1990 in contrast to upward trending figures for Germany and Japan over the same time period. The NSB regarded these and other data as indicating that “U.S. firms are losing, or have lost, their edge in research; continue to lose ground in the transition from research to product development/diffusion; and are losing still more ground in transition from product development to product

Table II.2. International Nondefense R&D Expenditures

Year	Nondefense R&D Expenditures (Billions of Constant 1987 \$)			Expenditures as Percent of GDP (%)		
	U.S.	Japan	Germany	U.S.	Japan	Germany
1971	50.2	17.0	14.1	1.7	1.9	2.1
1975	51.9	21.5	15.7	1.6	2.0	2.1
1980	66.5	29.1	20.4	1.7	2.2	2.3
1985	84.9	43.2	23.2	2.0	2.8	2.6
1990	94.1	58.8	27.3	1.9	3.0	2.7

Source: Selected data from the Report of National Science Board of the National Science Foundation (1992, Table A-10, p. 74). Estimated non-defense R&D expenditures include industry and university R&D and are as reported by the R&D performers.

implementation" (NSB, 1992, pp. 26-27). A *Business Week* article (Coy, 1993, p. 102) emphasized that companies are continually trying to keep R&D expenses as low as possible while trying to get more out of the R&D that is being funded.² It remains to be seen how well this strategy will work long term.

Upon comparing R&D expenditures on a company-by-company basis, world-wide, for top companies, reported levels for non-U.S. firms compared favorably with those reported for the top U.S. firms (Buder, 1991, p. 171).

Beginning in 1984-1985, the real annual growth rate of funded industrial R&D in the United States had declined to near zero and remained at that level throughout 1991 (NSB, 1992, p.10). The decline in the U.S. industrial R&D funding rate was attributed to a variety of factors, including: the poor U.S. economy, lack of funds availability from lower sales and profits, corporate restructurings, and the importation of high-technology from outside-funded research using a variety of sources. The observations paralleled the viewpoint that, while the United States holds positions of leadership in many technologies and industries, its leadership had been eroding to some significant degree. In general, there has been increased attention to gaining more return from the monies invested in R&D. There had been a shift in the 1980s from a higher emphasis on *exploratory research* and pioneering new markets to more of a short-term R&D focus aimed at serving existing markets (NSB, 1992 citing Bean's 1989 survey). Central and divisional R&D efforts became more focused on satisfying the new product and new process needs of commercial and business interests. Arguments in favor of promoting customer-focused R&D have been compelling for some time (Freundlich, 1991).

Support for Optimism

Along with the gloomy pronouncements of a declining productivity and its meaning for the United States, there have been some more optimistic

assessments. We need to make note of these perspectives because they increase our appreciation of how complex the subject of productivity is in relation to technological innovation. Baumol, Blackman, and Wolff (1989, p. 81), upon considering "the long view," concluded that for the entire post-World War II period, "there simply is no common pattern in the growth performance of the individual sectors and subsectors of the American economy." By the end of 1992, the volatility of relative competitiveness had become evident. Weakening economies were experienced in Germany and Japan. Difficulties continued among the newly independent nations, for example, Russia, emerging from the disbanded Soviet Union. At the same time, there were signs that the economic growth rate was beginning to increase in the United States. Because of the buying power of U.S. consumers, a stronger economic health in the United States is vitally needed for strengthening economies around the globe. The United States still leads the world in per capita GDP, but it is considered important for the United States to improve its social infrastructure and its educational system so that future challenges can effectively be met (Prowse, 1992, p. 34).

An even more positive assessment of U.S. competitiveness derives from a study by the McKinsey Global Institute of Washington, D.C., which was reported in *The New York Times* by Sylvia Nasar (1992, p. C1). The report showed that, while its growth rate has been slower since 1973, the United States continues to be the leading country in overall productivity, that is, in output per worker. An update of the McKinsey & Company findings in 1993 showed that, while Japan and Germany exceeded or equalled the United States in productivity in certain industries, *overall*, based on a total of nine industries, the United States still held a leadership position (Nasar, 1993).

The leadership position of the United States in productivity and competitiveness may continue to improve in relative terms, particularly if economies of key international rivals weaken further. Data in the *Business Week* article (Coy, 1993, p. 102) suggested that R&D investment by U.S. industry may have started to increase after several years of decline or relatively flat trending. In contrast, because of recessionary forces, industrial R&D funding was beginning to decline in Japan (Pollack, 1993). If such indications continue, the relative competitiveness position of the United States may be beginning, after some period of decline, to become more favorable.

Coupled with some softening of economic conditions in Japan, the *New York Times* has noted indications of strengthening in some segments of the U.S. economy (Pollack, 1993, 1994; Nasar, 1993; Chartrand, 1994). In the domain of intellectual property, IBM (at 1,085) assumed the world-wide lead in the number of U.S. patent awards received by any company in 1993

(Chartrand, 1994, pp. C1, C2). Other strong U.S. players were Eastman Kodak, General Electric, and Motorola. (However, six of the top ten companies receiving U.S. patent awards were large Japanese firms.) The improving situation for U.S. competitiveness was also documented by the Council on Competitiveness (1994), but with reservations because of some lingering problems.

In considering the above arguments on productivity and economic growth, one fact remains indisputable and is generally accepted: Certain countries, most notably Japan, have been growing much faster than has the United States in recent years. It is therefore considered appropriate that we explore this question of relative performance of the various countries more pervasively. We do that by examining comparative performance in the domain of patenting, the accumulation of intellectual property rights. While not a perfect yardstick, comparative patenting data provides further insights into relative levels of inventiveness. Patenting activity is central in importance to the theme of this book since it is one of the measures of technical creativity and innovation.

PATENTS AND PATENTING ACTIVITY

Invention patents provide evidence of potential for technological innovation. The process of gaining a patent in the United States evolves through an examination procedure which tests submissions for novelty, utility, and non-duplication of prior art. Indeed, a submitted application for a U.S. letters patent may be rejected if the examiner feels that the idea represents a logical or obvious extension of an existing patent. The invention must involve a physical object and must be unambiguously described by a professional drawing. Inventors need to have clear evidence of the nature and dates of their conceptions and the reduction to practice. Accordingly, the very nature of the patenting process requires both creativity in design and meticulousness in documentation. These elements are needed, not only to successfully gain a patent, but also to successfully defend it against any subsequent challenges or litigations.

The impact of patents on technical and business communities is global in character. Patents can represent important assets of the enterprise and, as a result, may become highly esteemed. Many constituencies are involved in the process of obtaining patents. There are the technical individuals, the inventors themselves, who are central in the process. There are the supporting players, the analytical specialists, the evaluators of performance, the librarians, the safety experts, those who assess marketing viability, and so on. There are the patent attorneys who supervise and coordinate the filings and follow-up, and who become involved in any ensuing litigations

or licensing activities. On the government side, there are the patent examiners, administrators, and adjudicators. On the business side, within innovating organizations, interest and involvement arise from all echelons, all along the innovation chain. CEOs, vice presidents, and functional area managers are all highly interested. To the inventor or inventors, patents represent major accomplishments which trigger recognition and rewards. In the domain of the technical individual, patents are an important vehicle for career advancement, especially when they enhance commercial or organizational aims. As important assets, patents provide mechanisms for entrepreneurship. Indeed, patenting, licensing, and related activities represent a major industry within the United States and among international communities.

The pervasive interest in patenting arises from many causes, as follows:

1. Patents provide a formal mechanism for excluding others from marketing the inventions in a commercial environment, that is, in the country of issuance. For utility patents, that exclusion presently exists for 17 years after the date of issuance, provided that the patents are properly maintained according to the ground rules.³ Patenting action is especially important for emerging technologies and may permit an organization or an inventor to develop a basic, proprietary position in an important new area.⁴
2. A patent is evidence that an invention represents a significant new advance over prior art. Therefore, the award of a patent contributes credibility which is important in technical and corporate domains and in the market place. The terms "patent pending" or "patent applied for" tend to communicate value in the marketplace. Use of such terms has to follow guidelines and is restricted to cases where a patent application for the item is on file at the Patent Office.
3. Patents are items of intellectual property. As such, they represent assets of the inventors or of the organizations to which the patents are assigned.
4. In the global arena, patents provide exclusionary protection for commercial development of a product or a process within the issuing country. That protection may be illusory, however, depending upon the existence of trade barriers or other barriers in the marketplace.
5. Patents serve as mirrors of technology and, as such, provide an important body of knowledge, a major literature, that is useful as a resource for inventors, scientists, and engineers. The patent literature can be used as a spring-board for achieving further advances.

Given the above, patents have become useful as indicators of technical productivity at the organizational, industrial, and national levels. At the personal level, patents provide important mechanisms for recognition, even for induction into exclusive societies.

There are also potential "downsides" to patenting. The patenting process is becoming increasingly expensive, both in obtaining the award and in assuring viability through payment of maintenance fees. Another downside is that patents may reveal elements of technology that competitors can use in developing saleable alternatives, that is, alternatives which avoid patent infringement issues. Whether to pursue a patent or not becomes a "judgment call" which factors in risks and benefits. There are instances where individuals or organizations prefer to keep new technologies as trade secrets, thus avoiding the patenting route. Those instances may be especially viable when subject products or processes are virtually impossible to decipher through competitive analysis.

Patenting Statistics

Data for the United States. According to the U.S. Patent and Trademark Office (USPTO), fiscal years (FY) 1991 and 1992 were record years for the number of patent applications filed in the United States (USPTO, 1992, 1993). The number of patent applications filed in 1992 increased to 185,446 from 178,083 in 1991. In FY 1992, 109,728 patents were issued, with 54 percent of those issued to U.S. residents (and 46% to non-U.S. residents). The figure of 54 percent for U.S. residents was higher than in the prior six years, but was only slightly higher than the 1991 figure of 53.9 percent (USPTO, 1993, p. vii). Since 1986-1989, patenting activity in the United States by domestic applicants relative to foreign applicants appears to have been running more strongly than in the preceding five years.

The situation was similar for issued patents, in relative terms. The USPTO reported that on a per capita basis, patent grants to residents of the United States "remained steady at 19 per 100,000 population during 1991;" while applications from residents of the United States "reached approximately 36.4 applications per 100,000 population in the 1990-91 time period, reflecting a substantial increase over the period prior to 1980" (USPTO, 1992, p. vi).

In FY 1993, some recent trends continued. Patent applications in the United States increased to 188,099 and patent awards numbered 107,332, while the proportion of foreign applications decreased again to 41 percent and the proportion of patents issued to foreign applicants also decreased slightly to 45 percent (USPTO, 1994, p.3).

The data suggest two important observations: first, that there has been a stronger emphasis on patenting in the second half of the 1980s and into

the 1990s. That emphasis may reflect greater stress given to invention and inventiveness. Second, the period throughout the 1970s and into the early 1980s was a period of low or flat productivity of patenting by U.S. nationals, in relative terms. In 1991, the upward advance in submission of patent applications by U.S. residents seemed quite favorable from the perspective of the United States. This is an implication which will be subjected to further analysis.

Patenting in the United States by Residents of Selected Foreign Countries. An analysis of filings and awards in the United States by residents of foreign countries sheds further light on the situation (USPTO, 1991, 1993). While, when measured by percentage, most nationalities yielded fairly stable or slightly declining numbers during the 1988-1992 period, Japanese nationals showed an increase from 28,218 filings to 38,135 filings in the United States, or an increase from 19.0 percent to 20.6 percent of the total applications filed. The level of about 21 percent of U.S. filings by Japanese residents in fiscal year 1992 far exceeded the levels obtained for residents of any other foreign country, as was the case from 1988-1991. That proportion diminished slightly for residents of Japan to a level of 19.2 percent of total filings in the United States in 1993 (USPTO, 1994, pp. 54, 61).

During the period between 1988 and 1992, residents of Germany ranked next below Japan in filings in the United States (but showed declining levels from 7.6% to 5.8% for this period). Filings by residents of the United Kingdom and France in the United States were below those from Germany and were in the range of 2.4 percent to 3.4 percent of the total filings in the United States (USPTO, 1992, 1994).

The data for patents issued by the USPTO to selected foreign residents showed similar trends for the same time period. U.S. patents awarded to Japanese residents ranged from 20.0 percent in 1988 to 21.4 percent in 1992, based on the number of the total awards for those years. Those proportions far exceeded levels of awards by the United States to residents of any other foreign country. Germany again ranked second in the same time period, but the proportions of awards declined from 9.1 percent to 7.3 percent of the total U.S. patent awards. The United Kingdom and France, with similar percentages in the three percent range, then followed. For the Japanese, the ability to continually gain such a relatively high proportion, about one in every five U.S. patents issued, seems to suggest a high level of quality for their submissions.

Going back to 1950, patenting activity in the United States by nonresidents was at a relatively low level, (USPTO, 1961, 1968). In 1950, the greatest number of U.S. awards to foreign applicants was to English nationals. Patent application filings in the United States by nonresidents began to increase in the 1950s, and the upward trend continued during the

1960s. The total nonresident filings increased to about 30 percent of all filings by 1971, peaking in the range of 45-46 percent in 1986-1989. By around 1976 up to the present time, Japanese nationals accounted for the highest proportion of U.S. filings by nonresidents, reaching a level of about 21 percent of all applications filed in 1992. Almost one-half of all the foreign resident patenting activity in the United States has been emanating from the Japanese. That is a remarkable achievement.

International Patenting Data. A greater understanding of patenting activities emerges, with implications for relative inventiveness, if we consider the full global arena. Fortunately, an abundance of data is available for most countries from the World Intellectual Property Organization (WIPO), which is headquartered in Geneva, Switzerland (WIPO, 1975, 1983, 1992, 1993). Patenting data for selected countries are given in Table II.3 for the years 1990-1991 (WIPO, 1992, 1993, p. xxxvii).⁵ The countries are listed in descending order according to the total number of applications filed within each of the top five patenting countries in 1990/1991. Data for the Soviet Union and Russia are not included in Table II.3 because of the enormous changes in structure that occurred during this period of time—changes in geography and in patenting law.⁶

Some interesting patterns emerge from the data in Table II.3. Japan ranked first, world-wide, by a large margin, with a total of 380,453⁵ applications reported as received in Japan in 1991. Next ranked the United States with 177,388⁵ applications received (less than one-half of the figure for Japan), followed by Germany, the United Kingdom, and France.

*Table II.3. World International Property Organization (WIPO)
Data for Patenting Activities Within Various Countries for 1990/1991*

<i>Country of Activity</i>	<i>Total Applications Filed</i>				<i>Total Patents Granted</i>		
	<i>Year</i>	<i>Number</i>	<i>% Change⁷</i>	<i>% NR⁷</i>	<i>Number</i>	<i>% Change</i>	<i>% NR</i>
Japan	1990	376,792	+5	12	59,401	-6	15
	1991	380,453	+1	12	36,100	-39	16
U.S.	1990	176,100	+9	48	90,366	-5	48
	1991	177,388	+1	50	96,514	+7	47
Germany	1990	110,349	+8	60	42,860	+1	61
	1991	109,187	-1	60	43,190	+1	61
U.K.	1990	97,891	+8	75	32,179	+4	86
	1991	95,533	-2	75	34,074	+6	87
France	1990	81,884	+9	81	35,149	+7	75
	1991	79,075	-3	80	35,581	+1	74

Source: Derived from data reported in WIPO (1992, 1993).

The picture was somewhat different upon considering the numbers of patents granted by these countries. The United States ranked first with 96,514 patents granted in 1991, followed by Germany, Japan, France, and the United Kingdom, all with less than one-half of the number of patents granted by the United States.

Patenting by Residents and Nonresidents Worldwide. It is also interesting to rank selected countries according to the increasing order of the ratios of patents awarded to nonresidents of those countries. This was estimated for 1990. Japan awarded relatively few patents to nonresidents (ca. 15% of their total awards), then came the United States (ca. 48% awarded to nonresidents), then Germany (ca. 61%), then France (ca. 75%), and then the United Kingdom (ca. 86%). The proportions of awards to nonresidents was also found to be very high for the Netherlands, Switzerland, Sweden, Belgium, Australia, Austria, Canada, and Denmark (ca. 84-99%). With few exceptions, those countries which awarded the lowest proportions of patents to nonresidents tended to be highest in patenting levels of the countries considered.

An examination of patent awards over a longer period of time, that is, from 1940 to 1990, reveals some interesting patterns (Table II.4). Certain countries have maintained a fairly constant proportion of awards to nonresidents; others have been increasing or decreasing that proportion. Japan has been decreasing its proportion of awards to nonresidents, while Germany, France, the United Kingdom, Italy, and Switzerland have increased theirs. The United States has risen to a substantial level of the number of awards granted to nonresidents, but that has leveled off and is decreasing slightly. Sweden, the Netherlands, Belgium, Australia, Canada, Austria, and Denmark have been holding steady at a high proportion of awards to non-residents.

Table II.4. Total Patents Granted by Various Countries from 1940 to 1990
(with percentages to nonresidents shown in parenthesis)

<i>Countries</i>	<i>1940</i>	<i>1950</i>	<i>1960</i>	<i>1970</i>	<i>1980</i>	<i>1990</i>
U.S.	42,323 (15%)	43,129 (10%)	47,170 (16%)	64,427 (27%)	61,827 (40%)	90,366 (48%)
Japan	6,716	4,272	11,252	30,879 (31%)	46,106 (18%)	59,401 (15%)
Germany	14,647	2,383*	19,666*	12,887* (50%)	20,188* (51%)	42,860 (61%)
France	9,650	17,800	35,000	26,117 (68%)	28,060 (70%)	35,149 (75%)
U.K.	11,453	13,509	26,775	40,995 (75%)	23,804 (78%)	32,179 (86%)

Note: *Data shown for Fed. Rep. of Germany.

Source: Derived from World Intellectual Property Organization (WIPO) documents (1975, 1983, 1992, 1993).

Table II.5. Patent Applications Filed in Selected Countries by Residents of Other Countries (1990 data)

<i>Country Filed In</i>	<i>Country of Residence</i>						<i>Total⁸</i>
	<i>U.S.</i>	<i>Japan</i>	<i>Germany</i>	<i>U.K.</i>	<i>France</i>	<i>All Other</i>	
U.S.	-----	35,771 (42%) ⁸	13,748 (16%)	6,946 (8%)	5,673	22,552	84,690 (100%)
Japan	19,578 (45%)	-----	7,780 (18%)	3,165	2,919	9,977	43,419
Germany	21,544 (32%)	16,387 (25%)	-----	5,325	5,561	17,642	66,459
U.K.	22,284 (30%)	14,644 (20%)	13,833 (19%)	-----	5,372	17,360	73,493
France	20,094 (30%)	12,471 (19%)	14,222 (21%)	4,876	-----	14,514	66,177

Source: Derived from WIPO (1992).

Patenting Activities by Nationals of Various Countries in Other Countries. It is interesting to consider data for patenting activity in 1990 by residents of selected countries in countries other than their own (Tables II.5 and II.6). Since such activity is presumed to be focused on the most viable inventions, marketing-wise, the data offers the possibility of providing another measure of relative inventiveness according to national culture. It is evident from Table II.5 that Japanese residents have been “targeting” the United States as the primary focus for patenting outside of Japan. That focus apparently arises because of the attractiveness of the U.S. market for Japanese exports. Residents from other countries, for example, from Germany, the United Kingdom, and France, are also active in filing in the United States, but their focus is somewhat more balanced in terms of patenting in various countries.

In 1990, residents of Japan filed almost twice as many patent applications in the United States as U.S. residents filed in Japan. Japanese residents were awarded almost five times as many U.S. patents as U.S. residents received from Japan (Table II.6). However, when *all* reporting countries are considered, U.S. residents file far more applications in other countries than do nationals of any other country. The United States remains the global leader in the “exporting” of new technologies. It is also evident that patenting is a globalized endeavor. Organizations that are generating new technologies seek to establish and expand markets around the world, and to protect their technologies in those markets. That is one of the important purposes of obtaining patents.

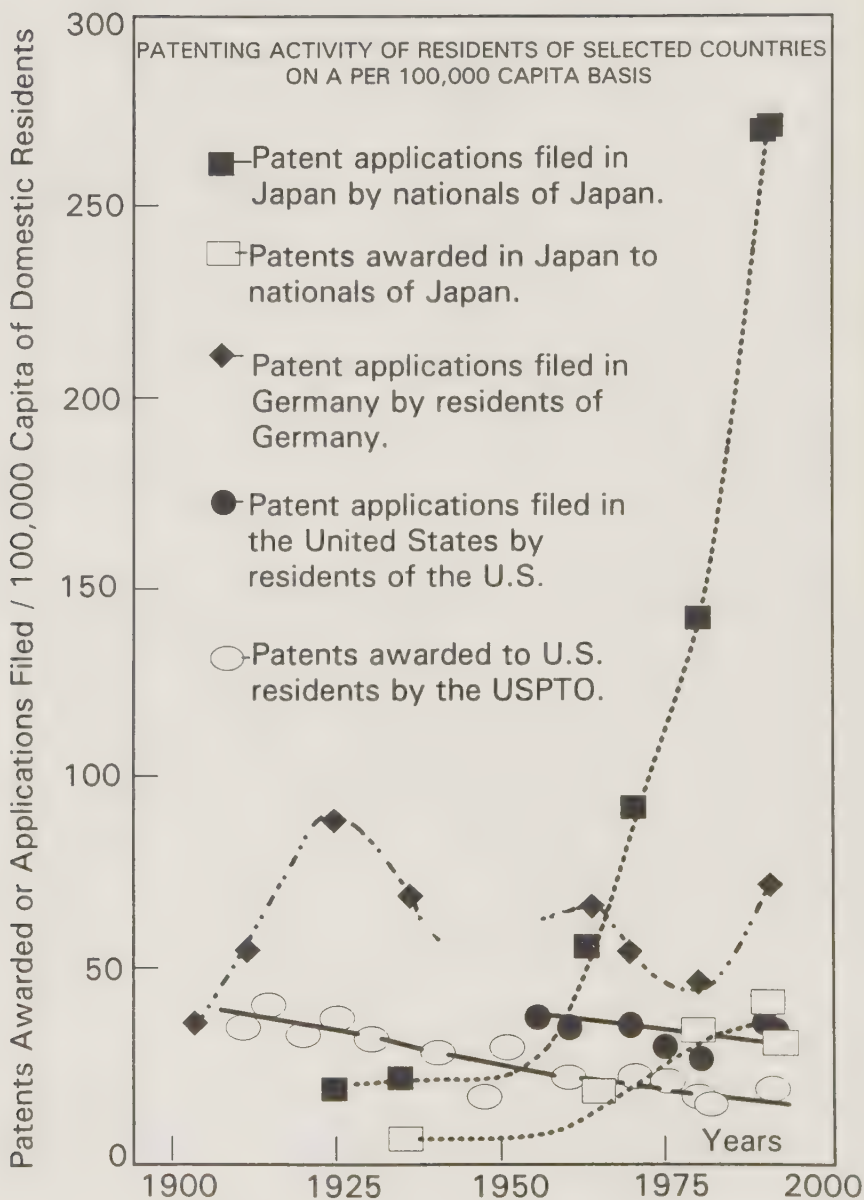
Table II.6. Patents Issued by Selected Countries to Residents of Other Countries (1990 data)

Issuing Country	Country of Residence						Total ⁸
	U.S.	Japan	Germany ⁹	U.K.	France	All Other	
U.S.	-----	19,524 (45%) ⁸	7,576 (18%)	2,790	2,866	10,217	42,973 (100%)
Japan	4,112 (46%)	-----	1,925 (21%)	465	695	1,834	9,031
Germany	7,289 (28%)	7,448 (28%)	-----	1,715	2,842	6,941	26,235
U.K.	7,132 (26%)	5,798 (21%)	6,349 (23%)	-----	2,524	6,015	27,818
France	6,526 (25%)	4,771 (18%)	7,064 (27%)	1,581	-----	6,290	26,232

Source: Derived from WIPO (1992).

Inventive Productivity According to Patenting Activity: The Long View. While data for numbers of patent applications and patent awards may not be a “clean” measure of inventiveness, with quality factors not necessarily included and patenting protocols varying from country to country,⁵ some very interesting trends become evident when data are compared over a long period of time and on a *per 100,000 capita* basis. Such data were developed for selected countries during the period from 1900 to 1990/1991 (WIPO, 1983, 1992, 1993), covering patenting activity by residents *within* their countries or primarily by nationals (Figure II.1). On a *per 100,000 capita* basis and within the United States, productivity in the *numbers of applications filed* was relatively flat for U.S. inventors.⁹ Results for Germans reflected higher levels over the entire time period, but with wider swings in activity levels. Both the United States and Germany experienced a slight dip in the numbers of filings received during the period between 1970 and 1983, a period which included the energy crisis and economic recession.

The pattern is strikingly different for Japan (Figure II.1). Application filings by Japanese nationals were at relatively low levels from 1925-1950, but had risen exponentially to reach a level of about 270 applications per 100,000 population by 1990. That level of activity is almost four times greater than the next closest country, that is, Germany. It should be noted that the relative patenting figures from one country to another are not strictly comparable because patenting practices vary from one country to another. The Japanese tend to include fewer claims per patent than some other countries, so there tend to be more applications written for a given technology.⁵



Source: Derived from World Intellectual Property Organization (WIPO) documents (1975, 1983, 1992, 1993).

Figure II.1. Patents Awarded or Applications Filed/100,000 Capita of Domestic Residents

Figure II.1 yields additional insights. It is evident that, when viewed over a long time period, the *per capita* patent output by Americans has been in a state of decline (cf. Clark, 1980). This simply means that numbers of patent awards to U.S. residents has been growing at a slower rate than has the population. Glismann and Horn (1988) have concluded from their study that other countries were catching up to the United States in inventive ability. However, while a smaller proportion of people *may* be participating in patenting activity in the United States, the factors of quality, sophistication, and importance are not embedded in the numbers. Certainly, lasers, transistors, microprocessors, complex pharmaceuticals, and advanced biotechnologies are much higher in sophistication than purely mechanical devices, for example, mousetraps. Yet, it may also be argued that, at the times they were invented, earlier inventions were also highly demanding of skill and creativity considering the level of tools that were available.

No clear patterns were evident for the Germans in terms of per capita patenting over a period of time. On the other hand, the data for Japan clearly shows a positive slope in patent output per capita during this same prolonged period, indicating a faster growth of patent productivity compared to population growth (cf. Shane, 1992). Are the Japanese becoming more inventive while Americans are becoming less inventive? That's what the data might suggest, if we go strictly by the numbers! This is an issue that merits further attention, further research.

Patents as Measures of Technological Activity. Although there are important questions of validity, patents have been widely used as measures of technological activity. For example, Archibugi and Pianta (1992) related patent counts and the number of citations in the literature to the cumulative level of R&D expenditures (technological size) and to the degree of technological specialization occurring within various countries. These investigators found that specialization in narrow fields decreased as the size of a country increased. This finding of an ability of larger countries to leverage diversification to various fields is interesting and is analogous to the ability of large corporations to spread their activities across many technological areas. A "technical economy of scale" may explain, at least in part, why many large corporations (such as General Electric and Motorola) can continue to pioneer new technologies for prolonged periods of time. Smaller organizations may have advantages of flexibility and willingness to risk, but they are also likely to be more focused on fewer areas because of more limited resources.

It has also been observed that principals tend to patent more extensively in diverse fields *within* their native countries, but they become much more selective in what they patent in other countries, that is, internationally (Archibugi & Pianta, 1992; Patel & Pavitt, 1991). One implication of this

finding is that the successful patenting activity of residents of one country in other countries becomes indicative of technological prowess.

Companies in the United States have apparently been refocusing their attention to the use of patenting activity as measures of productivity by R&D efforts. R&D proficiency is frequently assessed by the number of patent applications that are filed in any given year. An increased recognition of the importance of patenting would logically be expected to increase the number of patents filed and awarded in any given community.

Patents continue to be used as indicators of technological growth. A *New York Times* article (Broad, 1991) reported on an analysis of patents and the scientific literature that was conducted by *CHI Research Inc.* of Haddon Heights, N.J., showing that U.S. industry was lagging in relation to Japanese competition in the 1980s. The argument that Japanese patents are not always high in quality was discounted by the excellence of their products in many fields and in international markets. Dumaine (1992) also observed that during the 1980s the distance between the United States and Japan had been narrowing.

One explanation for the apparent preeminence of Japan in inventiveness derives from an analysis by Wakasugi (1992). Wakasugi felt that the genius of the Japanese has been manifested more by their skills in importing and adapting foreign technologies than by their creation of radically new, pioneering technologies. The argument is a familiar one. It emphasizes imitation and adaptation rather than fundamental creativity. But, the argument doesn't trigger much in the way of comfort given the virtual explosion of patenting by the Japanese. As Japan invests more and more strongly in basic research and focuses more on learning creativity as a systems approach, that pattern of adaptation may shift with time to more radical forms of creativity. As a result of sustained efforts to learn how to be creative, the Japanese have the potential of becoming even more competitive, even more innovative, than they have been in the past. We shall return to this issue in Chapter X.

Additional Insights from Data for Nobel Prize Winners. Perhaps the quintessential evidence of excellence in creating a new technology is receiving the Nobel Prize. With the exception of a very few years between 1901 and 1992, Nobel Prizes have been awarded to the top contributors in science, that is, for chemistry, physics, and physiology or medicine (*World Almanac*, 1992, 1993, 1994). By the early 1990s, approximately 400 individuals representing some 31 "nationalities" have received the awards either as individuals or by sharing the award with one or two others. Increasingly, as the twentieth century has progressed, awards given for the physical sciences have been shared. Awards continue to be given to individuals as such. Also, as the century has progressed, more and more

awards have been given to individuals who specified the United States as their nationality. Because several individuals have expressed more than one nationality, and because many individuals have emigrated to the United States from other lands, it is not possible to obtain a precise "fix" on Nobel Prize awards to individuals by nationality. With those reservations, approximations were made for the years from 1901-1992 (*World Almanac*, 1994). Individuals claiming the United States as their nationality predominated and represented approximately 40 percent of the awardees during this period of the twentieth century. British individuals (at about 15%) and Germans (at about 14%) ranked next, followed by the French (at about 6%). The Japanese awardees represented only about one percent of the total awardees. However, with five individuals winning awards (three in physics, one in chemistry, and one in physiology or medicine), the Japanese have demonstrated capability in this regard.

In terms of ability to create new science, the United States has clearly been preeminent. Indeed, based on the data, the twentieth century could justifiably be called the "age of U.S. science and invention." Of course, with the United States being a "melting-pot nation," Americans typically derived their heritages from other lands. Enrico Fermi was of Italian descent, Albert Einstein came to the United States from Germany, Yuan Lee is of Chinese heritage, and so on. There are many such examples.

As an example of the U.S. preeminence, in 1993 four North Americans (three Americans and one British-born Canadian) won Nobel Prizes for chemistry and physics (Browne, 1993). In the field of chemistry, Dr. Kary B. Mullis (an American) invented a new way of copying DNA and Dr. Michael Smith (the Canadian) designed an important new method for splicing components. The two Americans sharing the prize for physics were Joseph H. Taylor and Russell A. Hulse for their work in discovering the first "binary pulsar" (*World Almanac*, 1994, p. 77). Philip A. Sharp (an American) and Richard J. Roberts (British-born and working in the United States) shared the prize for physiology or medicine for independently discovering "split genes" (*World Almanac*, 1994, p. 77).¹⁰ So, American science is very much "alive and well" as we enter the twenty-first century.

It is not unusual for Nobel Laureates to be distinguished inventors as well as eminent scientists. The USPTO (1991) publishes booklets annually which list U.S. inventors who are in the *National Inventors Hall of Fame*. Of the individuals listed, several had also received the Nobel Prize for their contributions, including:

- Luis Walter Alvarez (physics): U.S. Patent No. 2,480,208—"Radio Distance and Direction Indicator;"
- Enrico Fermi (physics): U.S. Patent No. 2,708,656—"Neutronic Reactor;"

- Charles H. Townes (physics): U.S. Patent Nos. 2,879,439 and 2,929,922—"Masers;"
- John Bardeen, William Bradford Shockley, and Walter H. Brattain (physics): U.S. Patent No. 2,524,035—"Transistor;"
- Irving Langmuir (chemistry): U.S. Patent No. 1,180,159—"Incandescent Electric Lamp." (Dr. Langmuir received the Nobel Prize for his contributions in the field of surface chemistry and his research on the adsorption of gases.)

Summary and Conclusions

Analysis of this chapter, including information from cited studies, brings us to the recognition that U.S. technological leadership continues but it has been eroding in important areas in relation to international competition. The causes seem to be wide-ranging. They include internal management practices (emphasis on the short term and slowness in moving toward commercialization) and negative economic pressures (shortage of investment capital). The implications are clear. Since any society depends on technological innovation for achieving and maintaining a high standard of living, we must seek ways to promote better management practices in that general domain. That means doing a better job of planning and strategic management of relevant resources. It means doing a better job of managing the creation of new technologies, including new products and new processes. It means becoming more effective in transferring technology, that is, in bringing new technologies into commercialization or implementation more rapidly, both domestically and globally. But, it also means being able to sustain positions of competitive advantage by being smart in acquiring and maintaining proprietary positions through the management of intellectual property and the patenting process. These issues and the suggested perspectives on management represent the primary thrust of this book.

Insights on Technical Creativity from a Practitioner and Educator

Interview with Sharon R. Long, Professor, Department of Biological Sciences, Stanford University

Professor Long: In order to be successful in making creative advances in science or technology, it is very important to have the necessary tools. You also have to be in a place where you can come across new ideas and are able to bring things together. A creative idea is on the cusp of the unexpected.

Interviewer: How do individuals acquire the ability to be technically creative?

Professor Long: Breadth of training is very important. You need broad knowledge within a discipline. I was fortunate in doing my undergraduate work at Caltech (California Institute of Technology) and my graduate work at Yale. Caltech gave me broad exposure to physical sciences and mathematical analysis, as well as chemistry and molecular biology. Yale gave me exposure to broad areas within biology that were not represented at Caltech: these included botany, evolution, and ecology, and many areas of developmental biology. So I am convinced that you need to be aware of more than just narrow channels of information.

Depth of knowledge is also important. That knowledge is gained by actually doing a study in real depth. That's what a Ph.D. dissertation does for you.

Another ingredient which is required is that of fearlessness. In order to be creative you need to be fearless about experimenting, about trying new things.

While play is important, technical creativity encompasses a different aspect. You know that any new ideas will be challenged, will be put to the test. So, to be successful, you need to be fearless and still proceed, even when you know challenges will come.

Play and inventiveness are also important. Although I feel that I have these qualities, I can't think of how to cultivate them. I believe that I started out with the capability, with the notion of having fun while doing scientific research. Playing as an adult involves following certain rules. You get "points" for trying to excel within a system. In science, the rules are very tough because you're more interested in meeting an outside set of rules, rather than meeting self-constructed criteria.

It's hard to say why another person isn't doing it, isn't being creative. For me, the second part of creativity, the verification stage, is much more difficult than coming up with the initial idea. There is an impulse to go ahead too soon. A lack of time, either real or perceived, can prevent you from being as rigorous as you need to be. Whatever is rate-limiting can interfere with progress.

Interviewer: How do you overcome these pitfalls?

Professor Long: I don't have a specific system for doing that. I have a general sense of excitement that sustains me. That excitement has never left me. It's a positive attitude, a sheer enthusiasm, a feeling that this is interesting to me. These are things that make you pick up and get going. That's why I do it. For me, these elements come from my personal resources, from family, from religion, and so on. Others may gain strength from different sources; but whatever the source, it is essential to have this enthusiasm.

But even with this quality, this drive, individuals (students) still need to learn other aspects. They need to learn rigor, they need to become focused, and they need to develop sympathy for the ideas of others. So some students come in with assets, but you still need to teach them to be good scientists. Sometimes they have high levels of intelligence, but don't have the "fire." When that occurs, sometimes achieving something on their own results in "ignition." Sometimes even intelligent individuals can't be creative unless they are able to "come out of hiding." So, as a teacher, your role is to provide encouragement, to give confidence so that the creativity can come out. But, I think it is difficult to create creative potential if it isn't there already.

NOTES

1. Schumpeter separated concepts of innovation and invention, noting that innovations may derive from inventions but not always. At the same time, an invention may exist in a potentially viable innovation chain, but may never be commercialized and therefore be unrelated to innovation. According to Schumpeter, inventions supply the "raw materials for innovation," but do not guarantee that the innovation will result (Fels, 1964, pp. 428-438). In this text, innovations commonly involve inventions or technical discoveries as key elements in the process.

2. The \$94 billion figure of NSB (NSF) discussed earlier included non-defense R&D funds expended by universities and colleges, so it is higher than the \$70-79 billion figures reported by other surveys, for example, the survey in *Business Week* (Coy, 1993) for industry alone. The *Business Week* survey was limited to publicly held companies with sales at or above \$35 million. The NSB (NSF) survey included private and public companies and focused on company-performed R&D.

3. In this work, we are focusing on "utility patents," rather than design patents or patents for plants. Utility patents are granted for inventions or discoveries of new and useful processes, machines, manufactured articles, compositions of matter (new chemical compounds or chemical compositions comprising mixtures of ingredients), or any useful improvement of such.

Utility patents represent the category of greatest relevance in considering the generation of new technologies. Readers should refer to "Basic Facts about Patents," a publication of the U.S. Patent and Trademark Office (USPTO, 1990) (or a later edition) for precise definitions of terms and procedures relating to patents and the patenting process.

4. In order to provide special attention, certain areas have been identified as emerging technologies by the USPTO (1992, pp. 20-25). Biotechnology and superconductivity were identified as areas meriting special attention in 1991. The formation of these special examination categories reflects the desire of the USPTO to be responsive to needs which promote competitiveness and to assist in increasing the potential for diffusion of emerging technologies in the economic environment.

5. The WIPO patent data listed are for utility patents only. WIPO lists design patents as another category and these are not included in the tabulations. Accordingly, the WIPO patenting data in various tables run somewhat lower in magnitude than do the USPTO data discussed earlier. The USPTO data does include data for design patents and other data.

It should also be noted that patenting data from country to country do not precisely reflect relative patent activity levels because criteria for filing vary from one country to another. For example, filings by Japanese nationals tend to have fewer claims listed than do those by U.S. nationals (based on a communication with WIPO). That alone would effectively increase the numbers of patents filed by Japanese relative to Americans. Also, in Japan, the notion of "residence" is determined by one's nationality rather than by the actual location of residence. In other countries, non-residents and residents are simply determined by location. However, these and other differences do not alter the nature of the limited inferences that are drawn.

6. According to the WIPO reports (1992, 1993), the Soviet Union had 123,797 applications filed and 84,658 patents granted in 1990; newly formed Russia had only 30,180 applications and 1,215 awards in 1991. Based on a conversation with WIPO (in 1994), however, the figures are not comparable since the Soviet Union issued "invention certificates," which had much lower requirements for filing than Russia. The Soviet Union assumed ownership of the intellectual property. With the new law in effect in Russia, filing requirements were raised so that far fewer applications were submitted in 1991.

7. In Table II.3, "% Change" equals the change in value versus the preceding year. "% NR" equals the proportions of nonresidents filing applications or being granted patents in the given country.

8. In Tables II.5 and II.6, the "Total" column represents 100 percent of the applications from or awards to nonresidents filing applications in the country or receiving awards from the country specified at the beginning of the row. Values in parentheses are percentages of applications from or awards to nonresidents having nationalities indicated in the headings. For example, 42 percent of all the *nonresident* applications filed in the United States in 1990 emanated from residents of Japan.

9. Data for the British and French inventors on a per 100,000 capita basis were similar in magnitude to those for U.S. inventors, so are not shown in Figure II.1.

10. See Altman (1992) for additional contributions by Americans.

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CASE 1. GENERAL ELECTRIC RESEARCH AND DEVELOPMENT CENTER: A NEW FUNDING APPROACH

Sitting atop high knolls overlooking the Mohawk River, the General Electric R&D Center is surrounded by the myriad greens and blues of a beautiful countryside. The vaulting glass entrance-way and the enormous lobby seem to suggest that important and wonderful things have happened here, and that such events are continuing into the future. It's a spectacular setting. The receptionist offers a friendly greeting and comments about the loveliness of the day. She seems to be saying: Yes, we're important and big things are accomplished here; but we're friendly and low key and we enjoy what we are doing.

The General Electric Company (GE) was formed in 1892 from the merger of Thomson-Houston Company of Lynn, Massachusetts, with companies of Thomas A. Edison, including the Machine Works at Schenectady, New York.¹ Given that beginning, GE started with a rich tradition of invention, technology, and science. The Thomson-Houston Company manufactured arc lighting systems. Its founder, E. Thomson, was an accomplished inventor and a science teacher. Thomas Edison, with his enormous productivity of inventions and patents, including the incandescent electric lamp, the phonograph, and the motion picture projector, is considered "one of the outstanding geniuses in the world of technology."² The invention and refinement of the carbon filament incandescent lamp by Edison and his coworkers was done primarily during the period of 1878-1879. U.S. Patent No. 223,898 was awarded to Mr. Edison for the invention of the electric lamp. By 1892, Edison had obtained 682 patents, and during the remainder of his lifetime, he acquired an additional number of 410 to reach the incredible total of 1,092 patents.³ The formation of General Electric in 1892 occurred just two years before the expiration of Edison's electric light patent.¹ So at the outset, GE had to sustain substantial efforts for developing and patenting new and improved technologies in order to maintain and broaden its competitive position.

ORGANIZATION OF THE CENTER AND HIGHLIGHTS OF ACCOMPLISHMENTS OF GE RESEARCH⁴

The GE Research and Development Center resulted from the merger in 1965 of two laboratories, the GE Research Laboratory and the GE Advanced Technology Laboratory. The GE Research Laboratory had been founded in 1900 as the first U.S. industrial laboratory devoted to basic research. The

Advanced Technology Laboratory had been established in 1895 to provide advanced engineering and development capabilities. Innovations attributed to the Center and its predecessor organizations are highlighted as follows:⁴

- 1900-1910: a manufacturing process for the ductile tungsten filament still used in incandescent light bulbs today; discovery that filling a lamp bulb with inert gas at atmospheric pressure gives vastly improved performance over earlier bulbs prepared under vacuum conditions.
- 1910-1920: pioneering studies of the chemistry of surfaces by Irving Langmuir which resulted in his becoming the first U.S. industrial scientist to win a Nobel prize (in 1932, for chemistry); invention of a modern X-ray tube for medical applications.
- 1920-1930: first U.S. television broadcasts; improved processes for making super-hard, cemented tungsten carbide for cutting tools.
- 1930-1940: invention of a manufacturing process for deriving key building blocks used in the production of silicones, a new class of materials; first million-volt X-ray tube made commercially available.
- 1940-1950: major contributions to the World War II effort by developing electronic counter measures to enemy radar systems and devising new types of smoke screens for hiding fleets and invasion forces; invention of a modern combustor for turbojet airplanes.
- 1950-1960: the first reproducible process for making diamonds, used to manufacture GE's famous Man-Made⁵ industrial diamonds; two major advances in high performance engineered plastics: LEXAN⁵ resin (with uses ranging from locomotive windows to appliance housings) and a new polymerization method for making plastics by oxidative coupling (which led to NORYL⁵ resin).⁴
- 1960-1970: discovery of superconductive tunneling, a scientific phenomenon of major importance, by Ivar Giaever, which brought him a share of the 1973 Nobel prize for physics; invention of the Multi-Vapor⁵ lamp, a new and more efficient light source for stadium lighting and other large areas.
- 1970-1980: development of a fan-beam computed tomography medical X-ray scanner which became the world leader in sales; development of ULTEM⁵ resin, a new class of high-performance plastics ideally suited for electronic circuit

boards, automotive and airplane parts, and other applications.

- 1980-1991: growth of unique gem-quality diamonds that are the world's best conductors of heat; development of novel microelectronic devices for high currents and voltages; development and introduction of the world's best-selling magnetic resonance imager for medical diagnostics; development of a family of industrial-automation technologies, including high-power lasers, a computerized tomography X-ray inspection system, computer aided design and engineering software, and expert systems for various applications.⁴

Since 1986, the Center has been headed by Dr. Walter L. Robb, senior vice president for corporate research and development. The Center is organized according to functional areas of activity which include advanced systems, chemical research, electronic systems, engineering physics, environmental research, and materials research. Some 1,725 people—including approximately 1,100 scientists, engineers, and technicians—focus their efforts on the company's longer-range R&D needs. More than 475 of these men and women hold doctorates. Virtually all major scientific disciplines are represented on the R&D Center's professional staff.⁴

The R&D Center employs about five percent of the approximately 20,000 GE scientists and engineers who are engaged in research, development, and engineering, yet it produces about 30 percent of the company's patents and about 50 percent of the company's publications. For example in 1990, the R&D Center's staff was awarded 289 of the company's 888 patents. The Center's staff members contribute about 450 articles annually to the world's technical literature and present about 475 papers each year at professional society meetings.

Key research thrusts at the Center include: organic materials (plastics and silicones), structural materials (metals, alloys, composites, and ceramics), information technologies (artificial intelligence, advanced computing, communications, medical diagnostics, etc.), advanced electronics (power electronics, VLSI chip applications, microelectronic materials, and high-density packaging of microelectronic devices), productivity and automation (manufacturing systems, computer-aided design, testing and engineering systems, and laser/fiber-optic systems for welding and drilling), energy conversion and use (superconducting generators for aerospace applications, design of next-generation jet engines, integrated gasification/combined cycle systems, and advanced lamp technology), and biological science (biosynthetic routes to new chemicals and biological treatment processes for neutralizing toxic wastes).

Given this extraordinary breadth and depth of activity, the GE Research and Development Center qualifies as one of the world's largest and most diversified industrial laboratories.

***Perspectives on Creativity and
Innovation—Interviews with Key R&D Administrators***

In order to understand the operating culture and its origins, the following individuals were interviewed: Dr. Walter L. Robb, senior vice president of corporate R&D, Dr. Marvin Garfinkel, manager of planning for R&D, and Mr. George Wise, R&D Center communications specialist.

Each was asked to comment on what they considered to promote creativity and innovation, and what gets in the way. The discussions were held in 1991.

Interview with Walter L. Robb, Senior Vice President for Corporate Research and Development, General Electric Research and Development Center

Dr. Robb: Creativity starts back in childhood. Among scientists, it is evident as tremendous *curiosity*. I wanted to see how things worked and why they worked as they did. So, I took gadgets apart and reassembled them. That kind of curiosity, which comes from within, is essential for creativity.

I came to GE with a Ph.D. My initial industrial experience was with the Knolls Atomic Power Laboratory and then the GE Research Lab. At one point in my career, a top senior scientist thought he had a great idea for a project, but he couldn't work on it because of his managerial responsibilities. I was assigned the project even though doubtful of its success. Nevertheless, I attacked the project aggressively, even if it did mean proving this senior manager was wrong. Fortunately I didn't stop there. This stimulated my interest in permeable membranes, an area in which I received several patents, and did some of my best research—pioneering immobilized liquid membranes.

So, a second element in guiding creative, technical people is to give them direction, initially, but to ask them for proposals as the work evolves. Individuals need to have challenges which are relevant, but they need some opportunity to roam to be most creative. The

combination of initial direction, challenge, and relevance at GE is a very important aspect of what we do. And we expect individuals to move out from the initial directions to plot courses of action which can be more fruitful. Some individuals are good at this sort of thing, others are not. Some can generate novel proposals, creatively, others need continuing direction.

Another element, that is important, is that there needs to be a process of *recharging* and learning among creative individuals. They need to learn new technologies. This keeps their “*brains alive*.” Accordingly, we may ask an individual to become an expert in a new field and to do this for a year or so. We try to “bend” the individuals to a new discipline. This approach recharges individuals. In my own case, I actually learned a new technology every five years. This broadens your thinking and helps you to be able to expand your insights and to find better solutions.

This aspect of *broadening perspectives* is very important. For example, we had an individual who had 100 patents in a certain field. We then provided the opportunity to look into an entirely new field. After some period of learning he has become “world-class” in that new field.

There also has to be a *balance* between optimism and skepticism. A manager needs to challenge people, and be a critic, but he also has to be a perpetual optimist. For example, in developing superconducting magnets, we need to be concerned with reducing costs. If a researcher is designing a magnet using niobium at \$9/lb., we ask why can't we find a niobium supplier at \$6/lb., then at \$3/lb., and so on. While we encourage and are optimistic, we also question and challenge. In that way we help to ensure that the end-result is optimized.

Interviewer: It sounds like costs are very critical in your research and development programs. Savings must be very significant.

Dr. Robb: Yes, because of the competitive environment we are operating in, savings are very important both for us and for our consumers.

Interviewer: What else in your experience promotes technical creativity?

Dr. Robb: I'd like to add an additional point; a matter of “balance.” It is useful to find individuals whose talents or expertise balances one another. For example, we like to take a physicist who is able to come up with good ideas, who

knows fundamentals, and then combine that individual with an engineer who knows the practical side. So on various projects we see a balance of fundamentals with engineering-oriented perspectives.

Interviewer: What about the "negative" side? What really "messes up" creativity?

Dr. Robb: Having pessimists around, I call them "wet blankets." There are people who are negative, who keep saying: "It can't work." Such excessive pessimism is to be avoided.

Having people with poor common sense is also bad. Such people often "go off on tangents" and don't achieve the necessary checkpoints. A manager has to "rein those people in" when it is appropriate to do so.

A third negative arises when people are asked to solve a problem and, then after making progress, the company says they don't want it anymore. That's very frustrating. After too many such cases, individuals stop trying. They lose motivation.

And, finally, when management takes credit for the solution, that also has a negative impact on the creative individual's motivation.

Interviewer: You mean to say that creative individuals want credit, seek recognition for what they do. I thought they didn't necessarily think about that—that it was enough to simply work on a good problem?

Dr. Robb: Technical scientists definitely want recognition for what they do. That's an important "driver."

Interviewer: Which influences behavior more, facilitators or barriers?

Dr. Robb: In many cases, the scientists provide their own facilitators, their own motivation. So, perhaps, barriers can be more deadly.

Interviewer: In the context of our discussion can you tell me about two projects at the Center, one which was eminently successful and one less than successful? Why do you think these came out the way they did?

Dr. Robb: Yes, the *Fan Beam CT Scanner* immediately comes to mind as a highly successful project. Around 1974, EMI was awarded a patent for the first CT Scanner. The fellow who developed the first device, Mr. Hounsfield in England, received the Nobel Prize for that development. The device utilized a "pencil beam" which required that the individual or patient remain still for a substantial period of time while the beam was scanning. I was

running the medical business for GE at the time, and wondered if we could come up with a better scanner. Center R&D scientists conceived of a "fan-beam" approach, which greatly reduced scan time. It worked terrifically well! Within two years we went from eighteenth to number one in the world in this technology. And along the way EMI was acquired and is now a part of General Electric.

Interviewer: Why did this project immediately come to mind when I asked you about a successful project?

Dr. Robb: Why? Because of the speed with which we were able to advance into this new technology. We became the number one supplier, coming from way back, and in fact our design is now the standard technology in a two billion dollar industry. And it happened very quickly in only a few years time. That's *very* gratifying, and very satisfying to all the people on the project.

Interviewer: This feeling that you describe. Is it something like hitting a home run—with the bases loaded?

Dr. Robb: Yes, I suppose, but in slow motion compared to baseball. On the "less successful side," I can think of another project which followed the CT Scanner. That project involved the development of another innovative medical imaging product, again a quantum leap over its competition. We did come up with a product but there were many difficulties. Every "checkpoint" was late along the way. There was one problem after another. The evolving equipment and procedure became too complex, and was "a fix on top of a fix." In retrospect, you can almost sense these disasters. A pattern begins to emerge. You begin to get more explanations than results. If the objectives are being met, you don't need explanations.

The project leader is a key element for success. Some people are successful over and over again. But sometimes an individual who has not been highly successful will rise to the occasion and come through. It is the challenge to management to be able to pick the right people and to be sensitive to the need for adjustments as the projects proceed.

Leadership at the project level is very important.

Interview with Marvin Garfinkel, Manager of Planning, General Electric Research and Development Center

Dr. Garfinkel: To illustrate my background, I hold a Ph.D. in physics from Rutgers University. My university research focused on thermal conductivity. When I joined GE, I moved into semiconductor research. With work on VLSI (very large systems integration), I moved into management and later was involved with planning and resources management for the electronics area. Presently, I am manager of planning for the research center.

Considering technical creativity, I feel that people are either creative or they are not. It is a talent. So, you want to hire individuals who have this capability.

Interviewer: How do you determine whether a candidate for hire has the capability to be creative?

Dr. Garfinkel: First of all, in hiring Ph.D.s, you have the benefit of a "preselection process." You can read their theses and publications and derive a sense of their competency and productivity and originality. These elements contribute to an assessment of creative potential.

Secondly, you need an environment where that ability can "play." Our bent here is to get people involved early-on with the company's technical issues. We introduce them to problems. For example, a compressor might be wearing out too fast, a polymer may not adequately withstand very high temperatures, or a specific foam may not be consistently meeting specifications. We ask how can such problems be solved? So, there is focus, a context. We don't let people simply flounder. This approach is very important in GE research.

I believe basically that "you can't keep a good person down." So you need individuals who have the "heart to be successful." Such individuals will tend to overcome barriers. But, certain barriers are more harmful than others. For example, the absence of appreciation can be harmful. You need to nurture creativity with "attaboys" and other expressions of recognition. In general, it is important to maintain generally good human relations practices.

"Micromanagement" is another barrier. Given an objective, a manager should avoid laying out details. People should be allowed to "do their thing." There is

some risk to that. People may flounder about to some extent. But you need to let people have sufficient room to exercise creativity. So, excessive management should be avoided.

I think, overall, that both barriers and facilitators are an inevitable part of any environment. What is important is how individuals react to these elements. As noted earlier, successful creative individuals will somehow find a way to accomplish their goals.

Interviewer: Can you think of specific projects or approaches which illustrate some of these points—considering a successful project and an unsuccessful one?

Dr. Garfinkel: As a successful project, I can think of one in which I was collaborating with one of the “Coolidge Fellows.”⁶ We developed the world’s first continuously operating semiconductor laser. This was done around 1962-63. There was a specific problem which had to be solved. The problem was to be able to mount the device effectively. So, we designed a “package” to accomplish this objective. I feel a special sense of pride in thinking about this project. Why? Because the development was the first of its kind anywhere. We achieved our goal and the result was successful, especially as a technical development.

On the less successful side, there was a project in 1972-73 which comes to mind. We were developing a Schottky Diode, a solid state device, with certain operating characteristics. We were technically successful, but because of certain constraints, management changed its mind. So, the product had no commercial impact. But it was a substantial technical accomplishment.

Considering the *future*, we are now positioned with five research centers (dealing with chemistry, electronic systems, engineering physics, the environment, and materials). Each center has its own operating plans. We are also encouraging more autonomy. Twenty-five percent of the research time is now allotted to “autonomously” originated ideas, with 75 percent of the projects done in direct concert with business and with the business required to fund it. We seem to be a little more tolerant towards risk than we were in the immediate past. We believe that this posture will permit us to maintain our success for the long term.

Interview with George Wise, Communications Specialist, General Electric Corporate Research and Development Center

Mr. Wise: How do we manage creativity at this research lab? Insights to that question, in terms of the origins, may be gleaned from my book, *Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research*. Dr. Whitney was hired by General Electric to create what the company called the first American industrial laboratory devoted to fundamental scientific research.¹ Whitney's style was to manage certain people differently than others. He saw each individual as a different person in terms of their need for direction or freedom. It had to do with level of confidence. Some individuals lack confidence and, therefore, need to be directed. On the other hand, individuals like Dr. Irving Langmuir (hired by Whitney) were very proud and needed to operate autonomously. Dr. Langmuir was somewhat of a "prima donna" who had trouble getting along with certain supervisors. But, Dr. Whitney recognized Langmuir's personality and gave him extensive freedom, perhaps even more than was obtainable at a university. That management style paid off handsomely.

Others at the research center have received that high a level of freedom of action. For example, Ivar Giaever, awarded the Nobel Prize in physics for superconductive tunneling, also experienced a high level of autonomy in his research endeavors.

Research at the General Electric facility is now 75 percent applications and development oriented, with 25 percent of the effort devoted to exploratory research. This is somewhat different than in the time of Irving Langmuir. Langmuir could follow his own aims. But even at that time, there were specific problems to be solved. Langmuir addressed the problem of the blackening of light bulbs. He solved that problem by filling the bulb with an inert gas. Later, Dr. Langmuir became a Nobel Laureate for landmark contributions in surface science.

However, it should be noted that the experiences of Nobel Laureates are not typical. These generally are people who are very strong minded. They are people who generate a stream of successes. So, as Langmuir

did some thing, some substantial accomplishment, he was given more freedom. Autonomy has to be earned in our environment.

Langmuir was a very prolific contributor and a very prolific writer. He has composed 12 volumes of collected works. In these volumes, he did not separate pure research from applied research. The twelfth volume summarizes his important ideas.

Interviewer: Sometimes I think that the division between pure and applied research is somewhat artificial. The two can complement each other and make for a powerful synthesis. Important science can be derived from applications research; and there are many examples of how scientific understanding has triggered the development of new materials.

Mr. Wise: Yes, and Dr. Langmuir certainly thought that. The two perspectives were intertwined in this work which spanned from 1910 into the 1950s at GE. His most outstanding work was done in the 1910s and 1920s.

J. Herbert Holloman came from MIT to GE as Director of Metallurgical Research in the late 1940s. He had faith and believed that people should be left alone to do what they wanted. But with a shift to more of a business point of view, GE began to shift its focus and divided the effort into pure and applied research at roughly a 50/50 ratio. Giaever, another Nobel Laureate, was contributing during that period. He operated out of the pure research area and is responsible for superconductive tunneling.

During the 1950s, and into the '60s, there was a tremendous burst of faith in pure research. The 1950s were exceptional as a period of extraordinary scientific creativity. Man-made industrial diamonds and Lexan (a high-performance plastic), among many other important advances, were discovered and developed during that period.

Interviewer: Are there more "Langmuirs" emerging at GE?

Mr. Wise: We have a "Coolidge Fellowship" at GE which has recognized a stream of excellent contributors. Giaever was only the sixth or seventh member of many such individuals. The Coolidge Fellowship is a career award, so one has to have an enduring track record.

The structure of research at GE has changed since the 1950s. There is no pure research structure, as such, at GE. Pure research is "scattered around" the organization. So, pure research is at a lower level than it was in the 1950s. Why is that the case? GE has undergone changes in management in more recent times and that management has shifted the focus.

In the 1980s, there was an emphasis on increasing efficiency. As a result, certain research areas were dropped. Emphasis was placed on being more competitive in the short term. That perspective has "bottomed-out." I believe that the lab has gone as far as it can go in emphasizing applied research.

Our funding support system has again recently changed to provide "protected" funding of exploratory research at a 25 percent level. This is "assessed funding." There are "no strings attached." So pure research, at a significant level, is now on a solid basis.

GE is now trimmed down, and is organized as 13 businesses, each contributing billions of dollars in revenues. Each of these businesses is very strong so further substantial growth can come from any of several areas. The whole environmental research area is very important. This includes biotechnology and pollution clean-up using natural microorganisms. Biotechnology is being applied in the area of polymer chemistry to evolve new methods of processing. We are a leader in engineered plastics and are strongly committed to the process of industrial diamond manufacture. All in all, only about 25 percent of GE's business is concentrated in electrical applications. Of course, that includes research efforts in high temperature superconductivity, which potentially represents a very important area for our company.

So, it is evident that there presently is a multiplicity of "environments" at GE. The R&D Center is now operating several research centers. These are organized by technology areas, e.g., including chemistry, plastics, electronics, etc.

Interviewer: Given this tradition of excellence in pioneering new technologies, can you offer some insights on what helps individuals to be creative, and what impedes the process?

Mr. Wise: First of all, *you need individuals who have the capability* to be technically creative. Creative people bring into an organization a certain mindset of independence and a strong commitment. They have a focus and a direction, and, of course, a strong dedication to a scientific approach. Their commitment to fundamentals is generally articulated through simple modeling. They have the ability to express a problem or a solution in terms of models which get right to the core essentials of the matter. Langmuir, Giaever, and others of the Coolidge Fellowship, possessed these qualities.

A second attribute which promotes creativity is a willingness to be *receptive to practical problems*. You don't want people who are aloof. Langmuir liked to apply a fundamental approach in solving a practical problem. Along with Langmuir, Giaever, and Albert Hull and others might be characterized as "*modeling types*." This approach has led to many practical and novel solutions. For, example, one of our researchers invented the electric blanket, certainly a most practical product. Another individual at GE, Gilbert Wright, was searching for a new plastic material and discovered "silly putty." Another development led Dan Fox to Lexan polycarbonate resin, a high-performance resin with applications to many fields.

So, at GE research, there is an opportunity for individuals who want to understand things fundamentally, yet also want to solve practical problems. Perhaps, as an example, that is why the first preparation of man-made diamonds was done here.

And, of course, to complete the picture, we also have individuals who are excellent as "gadget people." These are individuals who can translate a concept into reality in very clever ways.

So I think in summary, we promote creativity by having excellent scientists, by the application of modeling, and by focusing on interesting and important practical problems. That framework leads to unique solutions and is the basis for good technical creativity.

Interviewer: Why has GE been so remarkably successful in pioneering new technical fields?

Mr. Wise: There are two important factors which come to mind. These are *technical diversity* and having *good problems*

to solve. Langmuir had a very good problem to solve—the blackening of light bulbs. In polymer science, Dan Fox had a good problem and that led to Lexan. The problem has to have a certain character in order to lead to the kind of advances we like to achieve. The problem must be scientific in nature, requiring substantial sophistication, so that it usually cannot be solved by accident or by crude approaches. The problem also must engender a practical solution which would normally be considered too practical by a research university.

But, at GE, it is not just the problem, it is the “problem meeting people.” When individuals with potential come here, something special happens. We have a “meeting of opportunity” with the scientific individuals of different backgrounds. In promoting these aspects, technical diversity at GE has become very wide-ranging. We have individuals who represent a very broad range of science-based technologies. We can effectively “blend disciplines” in attacking any given problem. So, I think that GE is most successful when it can combine technical diversity with good problems.

Interviewer: What about barriers to technical creativity?

Mr. Wise: A “*short range of emphasis*” is very disruptive. This arises when you are making rapid turns in direction, as was experienced in the 1970s and the 1980s. In that kind of environment, it is very hard to sustain the required effort. The work on synthetic diamonds was successful because there were four years of concentrated and sustained effort in arriving at the new technology.

I also believe that having an *artificial distinction between pure and applied research creates problems*. When these operating perspectives are separate, pure research becomes “too pure” and people don’t look at “boundary problems.” I feel that there are “acres of diamonds” buried in our own back yards, waiting to be discovered. If “pure researchers” consider problems to be too mundane or boring, they may miss exciting opportunities to develop new science and to arrive at very successful solutions.

In considering the relative impact of these influences, I feel that the *rapid change* of emphasis *hurts* more and, in a sense, overpowers things that

help. "Zigs and zags" are more serious now (as impediments) than in the 1950s. From the viewpoint of being able to sustain research effort, having "champions" is very important. Langmuir had Whitney, Giaever had Holloman. Our present leader, Walter Robb, seems to be striving for a balance. He feels that we shouldn't imitate at the expense of creativity; but he also focuses on the importance of implementation in making creative advances more successful.

EVOLUTION AND DESCRIPTION OF THE NEW CORPORATE R&D FUNDING APPROACH

Walter L. Robb, a principal architect of the new funding method, described its origins in a second interview at the center (December 1991).

Dr. Robb: In considering the new funding approach for corporate R&D at General Electric, I think it is important to note that there has been a shift, world-wide, to a greater emphasis on applied research. For example, the December 1991 issue of *Scientific American* describes a change in focus by Bell Labs. Siemens, Hitachi, and Toshiba have also increased their business-oriented R&D.

Interviewer: In relation to these changes, can you comment on what I have heard and read—that the U.S. has slipped somewhat in its ability to pioneer new technologies and to discover new science?

Dr. Robb: I suppose it has been slipping a little bit. But, one also has to factor in that we, as a nation, have been improving our R&D ties with the business sector. Science in the last 30 years has been undergoing a shift. That shift has been reflected in our evolving approach to R&D funding. Companies, in general, will do less basic research, and will tie more money to business-related programs than was the case in the past. For some time now, the government has been putting more money into research at universities and at the national laboratories for the country's R&D. Monies from the peace dividends are being redirected. The national laboratories are spending at a rate of about \$16 billion per year for R&D. The

national research council is giving more research dollars to universities, but most of that money is focused for supercollider research. So in today's economic climate, we are being more selective, even in the area of government funded R&D.

Interviewer: I have heard that science may be compromised in this country if we continue to increase the level of applied research, at the expense of basic research. Do you think that is true?

Dr. Robb: I think that is an exaggeration and even a misperception. It seems to me that there is generally some perceivable utilization for any scientific investigation. So the distinction between applied and basic research may be an artificial distinction. We can consider these arguments further but let's first consider the historical development of GE's new funding method for R&D.

The research laboratory at GE was founded in 1900. Up until 1946, funding of R&D was done through a general corporate allocation mechanism. Starting around 1946, corporate R&D was totally funded by a corporate assessment of the business units. The corporate assessment was guaranteed so R&D funding was supported year to year by this mechanism. Basically, the business units were providing about 95 percent of the needed funds. The remaining five percent of R&D funding came from contractual arrangements. At the time, there were two R&D centers, a general engineering laboratory and a central R&D lab. In 1965, with pressures to economize, the two R&D centers were merged, and we called the new division, corporate R&D. That arrangement continues today and with the concentration of all the people at one location, we have been able to accomplish additional savings, and greater efficiency.

In funding R&D for 1965, the new center was challenged to fund 25-35 percent of the total requirement from either specific business units or from the government, or from some combination of the two types of clients. The remaining 75 percent was to come from the corporate assessment. Over time, there evolved a large number of complaints from various sectors. Certain business units, which gained little from R&D, complained they were being assessed too much. Others felt some businesses were benefiting far beyond their assessment.

In October of 1986, a corporate officers' meeting was held to look at the different corporate services. The R&D Center didn't come out too well. I had just taken over as vice president of Corporate R&D, so it was a disappointing experience. At the same time, a study of R&D's productivity had just been completed by the Booz, Allen, Hamilton consulting firm. The Booz study was very favorable for R&D. It showed high contributions to company profitability and high levels of return on investment. But the CEO, Mr. Jack Welch, was not convinced. He felt more study was needed. So we put together a panel, at Mr. Ed Hood's suggestion, to study the situation further. The task force consisted of representatives of six key businesses of General Electric. Their study even addressed the need for any R&D corporate center within the company.

Interviewer: What at the time caused such an intensely critical examination of R&D?

Dr. Robb: Key constituents from businesses like the appliance business felt they weren't getting anything out of R&D. Plastics personnel were complaining that they were not getting sufficient control of what R&D did. Some radical ideas were proposed. The general manager of plastics suggested to Mr. Welch that the corporate lab should be split, with segments allocated to the business units.

The first meeting of the committee was held in March of 1988. During the first morning, the thinking was that the corporate lab does great work, but that the method of funding and program selection needed changing. So, the effort of the committee was focused on establishing new funding and decision mechanisms.

We reviewed an analysis that showed how much exploratory research was going on under the old funding schedule. We found 17 percent as exploratory research and 83 percent as applied research. Based on that analysis, we recommended that the assessment be cut to 25 percent, and to use those monies for exploratory research. That left 75 percent of the funding to come from contracts with business units or government agencies funding research of interest to the business units.

The first year of adoption was to be 1989. In 1988, we continued to assess the business units and to operate the same way as before. But in 1988, R&D began to define

what it was doing for each business, and to negotiate with the business units for support. We obtained agreement on sufficient projects to fund 75 percent of our budget and we have continued on this basis ever since. So at the present time, we are operating somewhat like a Battelle Lab, which is a contract research lab, but exclusive to GE businesses.

Interviewer: Are other companies using similar methods for funding research?

Dr. Robb: I suspect so, but I think the proportions of exploratory to directed research varies from company to company. For example, at several Japanese competitors, I believe the percentages are 50/50.

I should also note that we did something else to make sure that all constituencies within the company contributed to funding exploratory research. That was a change from the Reg Jones formula. Now every business, whether Financial Services, or whatever, contributes to about a level of 0.1 percent of their sales. Company-wide, 0.1 percent of \$50 billion sales represents \$50 million. The sum of \$50 million represents 25 percent of our total corporate R&D budget, which was at a level of \$200 million in 1986.⁷ The total budget for corporate R&D has remained fairly constant from 1986 to the present (end of 1991). So along with the new program, we have constantly maintained costs at the same level.

The R&D Center's performance was excellent in 1989.⁸ We had a record year for patents and an outstanding year of recruiting. At the same time, we kept our corporate R&D staff constant and continued to reduce our support staff and overhead rate. We have strengthened our ties with GE operations and have renewed our commitment to exploratory research. "Fairfield" has been amazed and delighted by our performance.

Interviewer: What do you consider to be the major issue or issues as you step back and look at the positioning of R&D at GE?

Dr. Robb: The issue is the 25 percent level for exploratory research. Is that the right number? The 25 percent number has given us the right numbers for filling our contractual obligations, for serving our business interests. But, is it the right number, long term?

Interviewer: Will important *new* things get done by this arrangement?

*Exhibit II.1. U.S. Patents Issued for GE and
Some Competitors (1990 Data)**

<i>Business</i>	<i>Company</i>					
	<i>GE</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Segment A	31	0	26	34	0	0
Segment B	51	0	4	13	1	0
Segment C	64	51	38	12	45	228
Segment D	28	3	12	4	6	8
Segment E	43	3	2	2	10	51
Segment F	11	2	26	23	19	11
Segment G	2	7	3	1	0	0
Segment H	83	0	0	0	0	4
Segment I	68	0	15	2	4	54
Segment J	183	3	6	0	2	7
Segment K	58	2	32	76	95	2
Segment L	20	4	27	41	44	3
<i>Subtotals:</i>	642	75	191	208	226	368
Segment M	16	5	227	245	38	2
Segment N	26	2	86	95	6	3
Segment O	82	18	249	284	126	27
Segment P	38	12	179	101	90	32
<i>Totals:</i>	804	112	932	933	486	432

Note: * Segments A-L are primary business segments of GE. Segments M-P are more peripheral to GE. Companies A-E are competitors of GE.

Dr. Robb: That's the question which we need to continually ask, and we are looking at it very carefully. We are considering the number and quality of patents that are issuing from our efforts, and in comparison with patenting production by competition. In order for such comparisons to be meaningful, the comparisons need to be made by business segment.

For example, we conducted an analysis of our U.S. patents issued in 1990 versus data for five major competitors (Exhibit II.1). The comparisons were done by business segments, which included: communications, appliances, lighting, industrial power systems, motors, electronics, transportation, air conditioning engineering, aerospace, materials, medical systems, semi-conductors, computers, consumer products, and others or miscellaneous. The results showed our patent output compared very favorably

with the U.S. patent output of major competitors that are operating in our markets.

In the main segments of our business (Segments A-L), we were awarded 642 U.S. patents in 1990, compared to a range of 75-368 for our primary competitors. Also, in every one of our businesses, we rank as either Number 1 or Number 2 in the world in terms of volume of sales.

We also assess our performance in patenting by other methods. From 1986 to 1991, our output of filed patent applications at corporate R&D (CR&D) has been fairly constant at 250-300 patents. Generally speaking, we file only the highest rated third of all disclosures that are submitted. Even with that degree of selection, our productivity is going up. Assuming that \$200 million is spent at CR&D, we estimate that about \$700,000 is spent for each patent application submitted. That's a good performance. We also recognize individuals by awarding bonuses for increased contributions of patentable ideas.

So, in essence, what we are saying is you don't just count the number of patents to assess technical creativity and innovativeness. You also need to consider the quality of the ideas. You need to ask how fundamental are the ideas, and how many technologies do they impact?

Interviewer: What about our ability to come up with "big bangs," our ability to create advances which are extraordinarily radical and effective? How will the new funding mechanism allow for that?

Dr. Robb: In terms of what competition is doing, I don't see any developments coming along now which would represent a major threat. Perhaps that will change. We always keep a watchful eye out for even the hint of such developments. On the other hand, if we consider our own royalty income versus "outgo" we see much more coming in as a result of licensing our technology, than is going out. In our businesses, there have been no real surprises for at least the last five years, since the discovery of High Temperature Superconductivity.

Interviewer: Do scientists argue for the need for more exploratory research; and if they do, how do you respond?

Dr. Robb: Every scientist thinks we should be doing more exploratory research, with no budgeting constraints, and with no time constraints. As an example of what I have

heard, some scientists read an advertisement by a competitor for a refrigerator which was claimed to be 30 percent more energy efficient than a GE refrigerator. So it was argued that we were not doing enough research.

We investigated and found that the claims were misleading. The competitor's refrigerator had six-inch walls, not four-inch walls, so it would require more space in the kitchen. Defrosting was to be avoided, so it was undesirable to open the doors too often. It came down to the fact that there really was no scientific breakthrough in the touted technology.

FINANCIAL PERFORMANCE OF CORPORATE GE

In their letter to GE's shareholders in the 1991 annual report, John F. Welch, Jr. (chairman and CEO) and Edward J. Hood (vice chairman and executive officer) reported that "1991 was a tough, terrific year for GE."⁹ The fine performance was attributed to changes that took place in the 1980s and proceeded into the 1990s. According to the top leaders, those changes positioned the company for high achievement in spite of severe global competition and a weakening economy.

In the early 1980s, the focus by GE's management had been on restructuring the company and on adding new opportunities. Layers in the organization were reduced. Unprofitable businesses were trimmed away. Productivity levels were increased throughout GE. More recently, the emphasis has been on improving performance in "softer" areas, such as, emphasizing speed, leadership, and "boundaryless behavior."⁹

Mr. Welch and Mr. Hood highlighted the financial performance of GE in 1991 by pointing to:⁹

- Growth of revenues by three percent to more than \$60.2 billion.
- Earnings growth of three percent to \$4.435 billion with earnings per share increasing by five percent.
- Adoption of a new accounting rule for retiree health and life insurance benefits, which reduced earnings by \$1.8 billion but used no cash.
- Growth of total cost productivity by four percent which is twice the rate for 1981-1982, a similar recessionary period.
- Return on equity close to 20 percent.
- An earnings increase of 17 percent for GE Financial Services (GEFS).

Exhibit II.2. Selected Financial Data for General Electric

<i>(Dollar amounts in millions; per-share amounts in dollars)</i>	<i>1991</i>	<i>1990</i>	<i>1989</i>
General Electric Company and consolidated affiliates			
Revenues	\$ 60,236	\$ 58,414	\$ 54,574
Earnings before extraordinary loss and cumulative effects of changes in accounting principles	4,435	4,303	3,939
Net earnings	2,636	4,303	3,939
Dividends declared	1,808	1,696	1,537
Earned on average share owners' equity	12.2%	20.2%	20.0%
Per share			
Earnings before extraordinary loss and cumulative effects of changes in accounting principles	\$ 5.10	\$ 4.85	\$ 4.36
Net earnings	3.03	4.85	4.36
Dividends declared	2.08	1.92	1.70
Stock price range	78½-53	75½-50	64¾-43½
Total assets	168,259	153,884	128,344
Long-term borrowings	22,682	21,043	16,110
Shares outstanding-average (in thousands)	868,931	887,552	904,223
Share owner accounts-average	495,000	506,000	526,000
Employees at year end			
United States	221,000	235,000	243,000
Other Countries	63,000	63,000	49,000
Total Employees	284,000	298,000	292,000
GE data (for GE, except GEFS)			
Short-term borrowings	\$ 3,482	\$ 2,721	\$ 1,696
Long-term borrowings	4,333	4,048	3,947
Minority Interest	354	288	283
Share owners' equity	21,683	21,680	20,890
Total capital invested	\$ 29,852	\$ 28,737	\$ 26,816
Return on average total capital invested	11.1%	17.4%	17.0%
Borrowings as a percentage of total capital invested	26.2%	23.6%	21.0%
Current Assets	\$ 15,964	16,199	\$ 15,671
Current liabilities	6,043	15,342	13,988
Working capital	\$ (79)	\$ 857	\$ 1,683
Property, plant and equipment additions	\$ 2,294	\$ 2,225	\$ 2,251
Year-end orders backlog	32,750	32,184	30,473
GEFS data (for General Electric Financial Services Inc.)			
Earnings before extraordinary loss and cumulative effects of changes in accounting principles	\$ 1,275	\$ 1,094	\$ 927
Net earnings	1,256	1,094	927
Share owners' equity	7,758	6,833	6,069
Earned on average share owners' equity	17.0%	16.6%	17.6%
Borrowings from others	\$66,420	\$57,400	\$47,905
Ratio of debt to equity (GE Capital)	7.80:1	7.77:1	7.80:1

(continued)

Exhibit II.2. (Continued)

<i>(Dollar amounts in millions; per-share amounts in dollars)</i>	<i>1991</i>	<i>1990</i>	<i>1989</i>
Total assets of GE Capital	\$ 80,528	\$ 70,385	\$58,696
Reserve coverage on financing receivables	2.63%	2.63%	2.63%
Insurance premiums written	\$ 2,155	\$ 1,981	\$ 1,819
Securities broker-dealer earned income	3,346	2,923	2,897

- Double-digit sales increases for Industrial and Power Systems, Lighting, Medical Systems, and Information Services, with GE exports increasing by 21 percent to \$8.6 billion.
- A 38 percent total return to share owners, including an eight percent increase in the dividend.
- A "few misses" were also reported, for example, for NBC (declining earnings) and for Motors and Plastics (weak markets and poor productivity).

The extraordinary growth of GE and its affiliates is reflected in Exhibits II.2 and II.3.

Upon completion of the first quarter of 1992, it was reported by Chairman John F. Welch, Jr., that:

GE's earnings per share were \$1.23, up 7% from a comparable \$1.15 in the first quarter of 1991. Consolidated revenues of \$13.5 billion in 1992's first quarter were up 2% from \$13.3 billion for the first quarter of 1991. Net earnings were \$1,058 million, up 6% from a comparable \$999 million for the first quarter of 1991. Growth in earnings per share outpaced growth in net earnings, reflecting the impact of GE's five-year \$10 billion share repurchase program. In the first quarter, the Company nearly doubled the rate of share repurchase from the first quarter of 1991, reflecting GE's improved cash generation capability, in part from faster order-to-delivery cycle times. The strength of our performance was a direct result of continued growth in Power Systems, Medical Systems and GE Financial Services. Results at NBC also improved over the first quarter of 1991. GE's operating margin for the first quarter was 11.7% vs. 12.1% in the first quarter of 1991, principally reflecting the recession's impact on short-cycle, high-margin business. At the same time, key U.S. order trends in several businesses were improving at the end of the quarter.¹⁰

Mr. Welch had confidence that 1992 would be another good year for GE.¹¹

Exhibit II.3. Summary of Industry Segments

<i>General Electric Co. and consolidated affiliates</i>			
<i>For years ended December 31 (\$ in millions)</i>	<i>1991</i>	<i>1990</i>	<i>1989</i>
Revenues			
GE			
Aerospace	\$ 5,326	\$ 5,614	\$ 5,282
Aircraft Engines	7,899	7,558	6,863
Appliances	5,451	5,706	5,620
Broadcasting	3,121	3,236	3,392
Industrial	6,928	7,040	7,059
Materials	4,722	5,167	4,929
Power Systems	6,185	5,804	5,129
Technical Products and Services	5,224	4,783	4,545
All Other	270	275	319
Earnings of GEFS	1,275	1,094	927
Corporate Items and Eliminations	(1,174)	(1,398)	(1,415)
Total GE	45,227	44,879	42,650
GEFS			
Financing	10,069	9,000	7,333
Insurance	2,989	2,853	2,710
Securities Broker-Dealer	3,346	2,923	2,897
All Other	(5)	(2)	5
Total GEFS	16,399	14,774	12,945
Eliminations	(1,390)	(1,239)	(1,021)
Consolidated revenues	\$60,236	\$58,414	\$54,574
Operating profit			
GE			
Aerospace	\$ 655	\$ 648	\$ 646
Aircraft Engines	1,415	1,263	1,050
Appliances	435	467	399
Broadcasting	209	477	603
Industrial	837	884	847
Materials	803	1,017	1,057
Power Systems	932	739	507
Technical Products and Services	746	595	589
All Other	238	201	176
Earnings of GEFS	1,275	1,094	927
Total GE	7,545	7,385	6,801
GEFS			
Financing	1,327	1,267	1,152
Insurance	501	457	361
Securities Broker-Dealer	119	(54)	(53)
All Other	(290)	(275)	(322)
Total GEFS	1,657	1,395	1,138

(continued)

Exhibit II.3. (Continued)

	General Electric Co. and consolidated affiliates		
	1991	1990	1989
Eliminations	(1,259)	(1,073)	(903)
Consolidated operating profit	7,943	7,707	7,036
GE interest and financial charges (net of eliminations)	(884)	(939)	(703)
GE items not traceable to segments	(623)	(621)	(630)
Earnings before income taxes, extraordinary items and cumulative effects of changes in accounting principles	\$6,436	\$6,147	\$5,703

CASE NOTES

1. The beginnings of GE and its rich tradition of industrial research are eloquently chronicled in a book by George Wise, titled *Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research* (New York: Columbia University Press, 1985). See especially pages 27, 67, and 72-73.

2. The quotation is from the booklet, *The National Inventors Hall of Fame* (Washington, DC: U.S. Department of Commerce, Patent and Trademark Office, 1993) p. 2. Pages 2-3 highlight the contributions of Edison.

3. See the book by Robert Conot, entitled *Thomas A. Edison: A Streak of Luck* (New York: Da Capo Press, 1979), p. 308.

4. Condensed from a GE pamphlet titled "GE Research and Development Center: Facts." Schenectady, New York, November 1991.

5. Man-Made is a trademark of GE. Lexan, Noryl, MultiVapor, and ULTEM are registered trademarks of GE.

6. A Coolidge Fellow at GE has received the R&D Center's highest honor for outstanding and sustained contributions to scientific research and development.

7. The sum of \$200 million refers to expenditures for corporate R&D, that is, for the GE R&D Center. Total company-provided expenditures for R&D (including corporate and divisional R&D) were \$1.40 billion (2.3%) in 1991, \$1.48 billion (2.5%) in 1990, \$1.33 billion (2.4%) in 1989, \$1.16 billion (2.3%) in 1988, \$1.3 billion (2.7%) in 1987, and \$1.3 billion (3.1%) in 1986. The values in parentheses are R&D expenses as percent of sales. In addition to this funding of R&D from the company (GE), funds for additional R&D come from outside customers (mainly from the U.S. government). The funding of additional R&D by customers has been substantial, at levels of approximately \$2.65 billion in 1991, \$2.79 billion in 1990, \$2.60 billion in 1989, \$2.45 billion in 1988, \$1.7 billion in 1987, and \$2.0 billion in 1986.

8. Dr. Robb's comments on the R&D performance indicators are from "R&D Frontiers-Winter 1990," GE Research and Development Center Annual Report, Communications, Schenectady, NY.

9. *General Electric Company 1991 Annual Report*.

10. *First Quarter 1992 GE Quarterly Report*, Fairfield, Connecticut.

11. The optimism expressed and the very good performance noted in 1992 continued through 1993, as indicated by the *General Electric Company 1993 Annual Report*.

Chapter III

Strategic Management

As manager, you have to impose some guidance. You have to have some vision of what you are, why you are, and so on.

—Darleane C. Hoffman, Lawrence Berkeley National Laboratories and University of California at Berkeley

Quick technology must be the hallmark of young firms, but if the older ones let the R&D function slow down, they can be in trouble as well.

—Keith W. McHenry, Senior Vice President, Amoco Corporation

It is important to have an atmosphere of pluralism, one which encourages the interaction of different perspectives.

—George E. Pake, Director Emeritus, Institute for Research on Learning

TECHNOLOGY, STRATEGY, POLICY, AND FLEXIBILITY

Interrelationships between technology and new product decisions were underscored by Ettlie and Bridges (1982, p. 3), who defined *technology policy* as “the long-range strategic plan of an organization that affects the development and adoption of new ideas, new processes and new products.” Technology policy is driven by the *technology strategy* that is adopted. Ford (1988, p. 85) defined technology strategy as “that aspect of strategy which is concerned with exploiting, developing and maintaining the sum total of the company’s knowledge and abilities.”¹ To a great extent, that knowledge derives from R&D. As organizations successfully develop and apply new technologies, they are creating core capabilities that become platforms for gaining competitive advantage. If technology strategy helps one to gain competitive advantage, then patent strategy helps one to keep that advantage from others (Berkowitz, 1993). Technologies and derived products are inseparably connected. Yet, we can partially distinguish between the two. Technologies are the core means, the basic processes, by which products work. Products are embodiments of relevant technologies which yield the desired properties or functions.

There are many examples which capture the relation between products and their technologies. Fundamental new and useful technologies which can be incorporated into desirable products have the effect of producing whole families of new products. Along the way, whole new industries can become created. For example, the development of microprocessor technology has made possible a whole host of new products, including personal computers, digital watches, electronic monitoring devices, and so on. The discovery of nylon was not only a mechanism for creating a new product, it led to many new products and the advancement of a major new industry, plastics. Such important new technologies also result in the formation of new disciplines of science such as the studies of polymer chemistry, microelectronic engineering, laser technology, and biotechnology.

The relation between products and product technologies is reciprocal. Fundamental new technologies lead to important new products. As new products diffuse into user environments, additional needs and opportunities are identified which then trigger additional advances. New technologies emerge from prior postulated strategies; but new strategies also emerge from the evolving technologies. Evolving technologies may be programmed in origin or they may be unanticipated and arise by serendipity.

In the field of strategic management, long-standing mechanisms have been available for rendering strategic choices based on a variety of contingencies (Hofer & Schendel, 1978; Glueck & Jauch, 1984). Avenues exist for control, feedback, adjustment, and readjustment. Technology policies become embedded in an organization's operating objectives, but also are reshaped depending on feedback from executing the objectives. Invention and innovation have special importance in the strategic management process. Inventions evolve during implementation. As these inventions evolve, they add new core competencies and become important assets for consideration in subsequent planning cycles. Achieved technical objectives become building blocks for future developments. Success breeds success.

Several milestone approaches are especially relevant in considering strategic options in technology and innovation management (Mintzberg, 1973; Miles and Snow, 1978; Porter 1980; Covin & Slevin, 1989; Covin, 1991). Mintzberg² (1973) observed that firms differ significantly in their approaches to strategic management. Each orientation encompasses different attributes which can be used in understanding the behavioral patterns of firms (Covin & Slevin, 1989, Covin, 1991). In the typology adopted in this text, it is assumed that all relevant firms are entrepreneurial to some significant degree, or at the very least are striving to be so. But, along with that, the importance of the contingency approach is acknowledged. All firms, including entrepreneurial ones, must frequently exercise adaptive, planning-oriented, or conservative policies in order to "shore-up" the advances that have been made.

The three generic competitive strategies of Porter (1980, 1985), that is, low-cost strategy, differentiating strategy, and focused strategy, represent alternative approaches for achieving competitive advantage. The differentiating strategy is especially relevant since its implementation commonly derives from new technologies and new products. The typology of Miles and Snow (1978) includes 'defender, prospector, analyzer, and reactor postures as four basic strategies that can be adopted by organizations. When applied to matters of technological innovation, both the Porter and the Miles and Snow options represent technology policy options that may be espoused by an organization and its members.

Strategy orientations can become relatively enduring, consistent with theories of organizational culture. The orientations can endure even when they become somewhat obsolete (Leonard-Barton, 1992). Top management teams become identified with postures that are associated with diversification strategies, so that "over time a reinforcing spiral probably occurs in which managers pick strategies to suit their competencies, successors are picked to suit the strategies, and so on" (Michel & Hambrick, 1992, p. 33). In spite of these forces, support is also evident for the viewpoint that strategic orientations exist in a continuum³ (Mckee, Varadarajan, & Pride, 1989, p. 32; Covin & Slevin, 1989; Covin, 1991). Strategic adaptability or flexibility is frequently observed among firms that are operating in shifting environments. Hambrick (1983, p. 25) pointed out that the "choice of strategy should be a function of the requirements of the environment and the type of performance being sought *at the time*."⁴ Organizations need to be able to rapidly realign themselves as markets change and become more or less favorable. In our adopted decision typology, all pertinent organizations are considered to be innovative to some degree; but they will embrace conservative strategies as needed to solidify their situations. Arguments for flexibility in plotting strategy and managing affairs have become increasingly eloquent (Harrigan, 1985). Huber (1989, p. 931) emphasized that flexibility will be an important requirement for survival in a "post-industrial society." The term "dynamically stable organization" is utilized by Boynton and Victor (1991, p. 53) in describing the organizational form that is best suited for the challenges that are anticipated. Managers must be able to be quick, but meticulous; products must be delivered with highest quality at the lowest cost. Innovations will have to be exceedingly clever and able to generate much consumer demand; yet will have to be available within relatively short product and process-development times. Coexistence of contrasting orientations arise as rational responses in these projected environments.

Accordingly, the challenges of the new age require the availability of new paradigms which are at once flexible, yet provide mechanisms for stability. The paradigms should also offer means for shifting from one operating

mode to another, and back again, thereby approaching simultaneity of contrasting, even contradictory, modes of operation. Such are the aims of the decision paradigms that are presented in this book.

DECISIONAL ENVIRONMENTS OF INNOVATION

The levels of innovation management that have been introduced to this point are primarily intended to focus on decisions within organizations, as influenced by their surroundings or operating environment. Organizations are functioning in *open systems*. Accordingly, decisions must be made with full understanding of the external environment of the organization, at the time of the decisions and projecting into the future. Various categories of the environment that impact on decisions are noted in the open systems model of Figure III.1.

The model includes elements of the competitive environment (Porter, 1985, p. 6), and the general environment, that is, economic, legal, political, social, ecological, and ethical factors (Pearce & Robinson, 1991, p. 76). The *international* arena is also included since some form of globalization is inevitable in the modern era. Technology windows and forces impelling strategic alliances have been added to the model because these elements also influence the nature of the environment of the organization. An environment that is favorable for the development and introduction of a new technology may exist for a relatively short period of time. Resources may also be available for a finite time period. In a similar fashion, opportunities to link with other organizations in synergistic alliances may be fleeting and may require action at specific points in time. Thus, it is important to note that the environment encompasses an array of elements, but the nature of the array is always changing, and especially so in the domain of technological innovation.

It is also important to note, subject to certain dilemmas, that some decisions should not be made purely on the basis of contingent considerations. There are some decisions which are governed by universalism. These include needs to operate legally, ethically, and with social and environmental responsibility. Organizations need to operate in ways which promote survival, in ways which do not invite sanctions, so that attention can be given to activities promoting growth without undue distraction. On the other hand, it is also recognized that moral and ethical dilemmas can arise which make certain decisions very difficult. For example, such issues can involve conflicts between benefits to the few versus benefits to the many, or conflicts that arise when cultures with distinctly different values are engaged. Such dilemmas have to be resolved on a case-by-case basis.

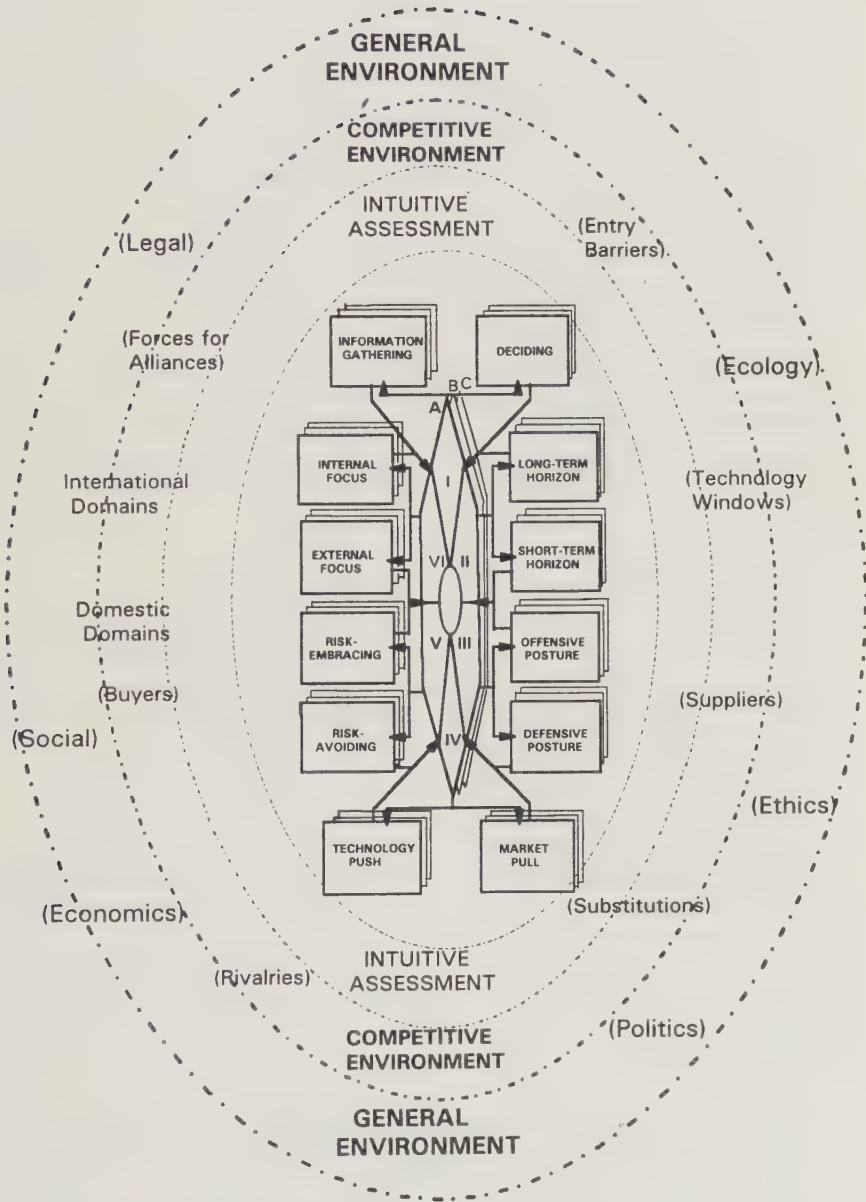


Figure III.1. Decisional Dichotomies in an Environmental Field

Another "universal," that is very important, is the need to subject every decision to a test of consistency with "intuition," or to "feelings," prior to its adoption and implementation. Intuition was identified in a decisional dichotomy relating to creativity management (Chapter I, Figure 6). It is also relevant to employ intuition again in the operating environment before finally operationalizing the choices that are made. Questions should be posed in relation to the operating environment, such as: How do I feel about the decisions? Do I feel comfortable about where we are heading? Do I prefer different solutions, different routes, even though they run counter to the prior levels of analysis? And why do I feel as I do? It is important to factor in such feelings; indeed it is often desirable to "run" with them, especially when the final decision maker has substantial experience and a proven track record of success.

Accordingly, in the realm of technological innovation, several environments are germane. First, there is the environment that is external to the firm or the organization, the macro-environment, which consists of the external stakeholders and the competitive environment. The external environment also includes a category of special interest, that is, the "environment" or "ecology" itself. Ecological issues have become increasingly important in strategic management. Then there is the internal operating environment of the firm, its groups, functions, and activities. Finally, there is the environment of the individual, the micro-region, which is especially important in considerations of creativity. Micro-environmental issues are reserved for discussion in Chapters VI and VII. In this chapter, we are concerned with the organization's external environment.

The economic environment has a pervasive influence on all aspects of technology and innovation and in turn is influenced by those aspects. In periods of robust economic growth and prosperity, as was experienced in the 1950s into the 1970s, there were many factors which made it easier to innovate. Capital was available to sustain rapid growth and expansion. Consumers during that period were almost endlessly insatiable in satisfying pent-up demand that had existed in earlier periods. Indeed, there was a feeling during the 1950s that one simply had to develop a product, call it new or improved, and wait for consumers to jump at the chance to buy it. Those, perhaps, were the halcyon days that may not return in the foreseeable future.

When economic conditions are more difficult, as was the case internationally during the late 1980s through the mid-1990s, efforts to innovate become especially challenged. An interesting paradox is created. In difficult economic circumstances, the need for innovations which fuel economic growth become especially acute, yet the availability of resources for supporting innovation becomes increasingly constrained. In essence, innovators must do more with less (Coy, 1993).

The Regulatory Environment

Regulatory and policy issues relating to innovation broadly impact on stakeholders who reside within and outside companies or organizations. Within organizations, there are the enterprise managers, the practitioners of innovation, and the rank and file employees. All organizationally connected individuals depend on innovation to some extent because of its relationship to the growth and survival of the enterprise. Evolving products and processes therefore must meet marketing objectives *and* regulatory requirements to permit entry and to enhance longevity in the marketplace.

Outside the organization, there exist broad constituencies which include the consuming public and their representatives in various governmental agencies, including federal, state, and local bodies. Agencies focus on protection of consumers, the environment, the economy, or the workplace, depending on the nature of their specific charters. They are interested in promoting safety and efficacy of products as well as ethical behavior by organizational members to prevent abuses. So, in effect, elements of the operating environment tend to encourage innovation, but also to control it as well.

In general within the United States, there is an environment that encourages innovation and entrepreneurship. It's "easy" to start a business, but companies and individuals have to "play by the rules." Businesses can be formed easily as proprietorships, partnerships, through articles of incorporation (charters granted by the states), or with funding grants from the Small Business Administration. Sustainability or survival is another matter.

Technology-based enterprises can obtain protection for new technologies through patents and trademarks (administered through the Department of Commerce) and for textual material through copyrights (administered through the Library of Congress). Use of patents, trademarks, and copyrights by others than the originators may be obtainable through negotiated licenses or permissions.

The other side of the "regulatory coin" is designed to prevent abuses and to protect consumers and workers. Innovation is regulated through a variety of laws or regulatory agencies, including: the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), the Consumer Product Safety Act (CPSA), the Occupational Safety and Health Act (OSHA), the Clean Air Act, the Clean Water Act, the Toxic Substances Control Act, the Resource Conservation and Recovery Act, the Emergency Planning and Community Right-to-Know Act, the Federal Trade Commission, and various local regulations and agencies. Those who are engaged in the practice of innovation must be familiar and updated on regulations so that problems can be anticipated and avoided. The protocols for meeting requirements impact strongly on time lines for planning and

implementation of new products. For example, under FDA regulations, Investigative New Drug applications (INDs) and New Drug Applications (NDAs) are required for new products that embody some type of "medical" claim, explicit or implied. Because of the extensive documentation that is required, new drugs may require 10-15 years of R&D prior to commercialization.

U.S. industry has demonstrated a strong commitment to addressing environmental issues (Rushton, 1993). That commitment impacts on strategic planning, the allocation of resources, the need for strategic alliances, and technology transfer across international boundaries. As part of this broad effort, industry is seeking opportunities for innovation in the environmental sector, including, as examples, new methods of manufacturing for low environmental impact, creative packaging techniques, and the marketing of "green products." Accordingly, the ecological environment provides *both challenge and opportunity* to those engaged in technological innovation (Gore, 1992). Thus, as with so many other aspects inherent in the innovation process, ecological considerations add yet another requirement for achieving an appropriate *balancing* of factors in order to be successful.

Given the state of flux that continues to exist in the environmental arena, the question remains: Is the environment and the development of environmentally positioned products an opportunity or a potential threat, given the ambiguities that exist? If both are true, then under what conditions? Certainly, the environment and ecology should be pursued in a responsible manner by all concerned? But what does that mean—in precise terms? Another issue relates to the question of timing and "windows of opportunity." When an area is young, even embryonic, opportunities for growth, commercial exploitation and societal impact are at their highest levels. But, in regulated areas, and particularly where appropriate perspectives and policies are emerging, one may be dealing with very dynamic situations where the environmental policies are unclear. Given those scenarios and the windows of opportunity, is it better for a new player to enter the arena early or to wait until issues are clarified? When all the issues have been entirely clarified, it is usually too late for an innovator to enter a new field and expect to be among the first entrants. Opportunities would be lost.

These are the dilemmas that face innovators who are striving to pioneer new fields. Similar situations have arisen or are arising in the fields of telecommunications, information highways, and biotechnology, just to name a few examples. How does one deal with such dilemmas? There are no all encompassing recipes, but two general perspectives seem quite important. The first is that innovators must operate ethically and with common sense even when official guidelines have not been published. That

means that sound professional judgment must be exercised. Second, at the earliest possible opportunity, innovators should proactively become engaged in the process of writing the guidelines that will eventually emerge. Along with these aspects, it is important to note that innovations are crucially important in improving the environment. That has been the case in numerous examples, such as, the development of catalytic converters and solar energy technology. Fortunately, the U.S. government is interested in encouraging innovation at the same time it strives to protect society. That philosophy is relevant at all levels of the process of innovation.

At the Center of the Environment: The Chief Technology Officer (CTO)

The environs and role of the CTO in decentralized firms have been excellently developed by Rubenstein (1989) in his text. We only wish to expand on that a bit and underscore some important aspects. The CTO is a pivotal element in any organization that is engaging in technological innovation. His or her job is especially challenging given the many dimensions that must be managed effectively in order to be successful. The CTO is a technical leader, a key communicator, and a motivator of creative individuals and professionals. Credibility is very important in what the CTO does. Inside the organization, the CTO has ongoing key interfaces with marketing, sales, manufacturing, finance, the CEO, etc.; and outside, with the legal and regulatory environment, with social, consumer, and environmental interests, with economic interests, with technology sectors, etc. The CTO is at the fulcrum of crucial decisions which must be made. His or her job is "on the line" very frequently, yet decisions must be made professionally and with consideration of various stakeholder interests. The CTO must have wisdom intermingled with cunning, must be strong and persistent, yet must know when to adapt and adjust. He or she must be input and output-oriented, must perform what is needed, must be politically astute, and must be able to say "no" as well as "yes," and so on.

In order to have credibility with the technical staff, the CTO needs to have a track record of significant accomplishment in the domain of technological innovation. It is not at all unusual for CTOs to continue contributing in areas relating to their technical expertise, though at some diminished level. Ideally, the CTO will have important inputs of creativity and practical experience and will participate effectively in ad hoc situations. Yet the CTO also has to be effective in participating in those macro areas that relate to the organization's interests by participating in the business aspects and in the strategic management of the organization.

It must also be recognized that, by definition, the CTO cannot be doing the same things tomorrow as he or she did today, even if that was done incredibly well. The charter of R&D is to come up with *new* things. In R&D,

getting stuck in doing the same things, long term (or even short term), constitutes failure. That represents an ongoing challenge, but also an especially important enjoyment for CTOs.

Are such individuals possible? Do such “renaissance persons” exist? Given that any CTO cannot long survive without such qualities, the answer is clearly “yes.” And considering the increasingly turbulent environments that are expected in the future, greater and greater demands will be placed on these individuals to be expert in various disciplines, yet also to be multidimensional and flexible.

STRATEGIC CHOICES: FLEXIBILITY THROUGH DECISIONAL DICHOTOMIES

In a flexible operating environment of innovation, any of the following choices may be invoked at any point in time:

- Strategic Domain (A):
- I. Information Gathering versus Deciding
 - II. Long-term versus Short-term Horizon
 - III. Offensive versus Defensive Strategy
 - IV. Technology Push versus Marketing Pull Orientation
 - V. Risk-embracing versus Risk-averse Strategy
 - VI. Internal versus External Focus.

In this chapter, the decision criteria relating to strategic dichotomies II, III, V, and VI are discussed. Specific criteria for selecting one option over another are given in the following sections. Dichotomy IV, involving the technology-push and marketing-pull modes, is considered to be of special importance and is covered in depth in the next chapter. The criteria given for Dichotomy I (Table I.2), information gathering versus deciding, are fairly self-evident and would appear to warrant no further elaboration.⁵

Long-Term versus Short-Term Planning Horizon

Table III.1 offers specific selection criteria for emphasizing a long-term or a short-term planning horizon at any given point in time. The need for facility in addressing *short-term* requirements stems from competitive forces and a rapidly changing environment (McDonough & Barczak, 1992). Technologies are changing rapidly. Market needs are shifting. Product life cycles are becoming shorter. Global competition is increasing with new players frequently entering the arena. In weakening economies, there also

*Table III.1. Specific Selection Criteria for
Long-Term versus Short-Term Planning Horizon (Dichotomy A-II)*

General Criteria	Conditions Favoring Selection of:	
	Long-Term Planning Horizon	Short-Term Planning Horizon
1. Performance to date and projected	—High performance is obtained from long-term commitment of resources to pioneering new products and technologies. —Long product life cycles. Organization can invest financial resources long term. Organization seeks to dominate certain markets, long term.	—High performance is obtained from ability to swiftly pursue opportunities in an environment that is highly competitive. —Short product life cycles. —Organization is flexible and can pulse investment of resources. Organization seeks to maintain shares by frequently innovating.
2. Organizational culture	—Characterized by patience; committed to long-term growth.	—Characterized by commitment to frequent change.
3. Influence of stakeholders	—Commitment is for the long haul, managers are credible for maintaining that focus.	—Given priorities, there is high insistence on short-term profit performance.
4. Predilections of Chief Technology Officer (CTO)	—Prefers developing advanced technologies, unique products and building new core capabilities. Willing to sustain commitment of resources, with related risks.	—Seeks to sustain support by financial coalitions that focus on short-term profit performance. —Emphasizing incremental R&D over pioneering R&D.
5. Willingness to change	—Decision makers persist in “staying the course” to achieve a major distinctive competency or competitive advantage (Technology-Push)	—A fluid, adaptive posture exists which permits rapid responses in a dynamic environment, one that welcomes change. (Marketing-Pull)

tends to be an increasing emphasis on shorter term research. That arises from the business-driven constituencies that aim to maintain and improve “bottom-line” performance (Perel, 1990, p. 7). Needs ensue for quicker response times, for faster new product development. Inevitably, an emphasis is placed on short-term planning horizons. Rothwell and Whiston (1990, p. 193) suggest that in order to achieve faster response times, a premium is to be placed on “corporate integration” activities over “functional differentiation,” even to the point where boundaries within organizations evaporate.

However, there are potential downsides to the short-term perspectives. Even while the competitive position of the organization may seem attractive in the short run, the *capability for long-term growth*, that is, the ability to sustain competitiveness, may become compromised. An excessively short-

term focus has been linked with erosion of competitiveness: Michael Porter, in a 1992 interview, noted that the U.S. system of allocating investment capital, long term, had been running at a much lower level, by percentage, than was the case for Japanese and European companies (Lohr, 1992). Among other variables, using a short-term perspective in planning for innovation was listed by Maciariello, Burke, and Tilley (1989) as being among flawed approaches by U.S. firms. In a worst case scenario, organizational fixes that decentralize an R&D capability under business unit control can limit the ability to address important future needs (Arnold, 1992). To avoid these and related problems, recommendations have included: maintaining significant levels of independence for R&D (Arnold, 1992), modifying performance measurement and reward systems to encourage long-term perspectives (Maciariello, Burke, & Tilley, 1989), and more actively engaging business heads in strategic planning and control processes (Goold, 1991).

Given that a case can be made for both long-term and short-term perspectives, Table 1 provides decision making criteria for achieving a suitable focus at any point in time.

Offensive Mode versus Defensive Mode

By definition, innovating or entrepreneurial organizations exercise offensive strategies. Competitive positions are expanded through diversification, by introducing new products or services and by pioneering developments, gaining market share in the process. Yet, in order to consolidate positions, organizations must also become defensive to some significant degree, again, at various points in time. Table 2 provides specific criteria for selecting either an offensive or a defensive posture in dealing with the operating environment. Innovating organizations invite serious competition when they are becoming successful with a new development. Competitors may react by introducing similar offerings (even generics) at lower costs while avoiding infringements, or they may counter with innovations of their own, thus expanding the options of customers. In striving to maintain their positions, pioneering firms can respond in a variety of ways. They can build proprietary positions through effective patenting programs and by maintaining trade secrets. They also can build brand loyalty and introduce switching costs which discourage users from moving to alternative offerings. And given that the best defense is generally achieved through the best offense, a strategy of continuous, aggressive innovation will prevent competitors from overtaking and making obsolete a firm's products. Competitors then become mired in a game of "catch up." So inevitably, if an organization embarks on a strategy of innovation, it must continue to innovate in order to survive. But it also must be able to maximize the benefits of innovation by operating at the highest quality and lowest cost.

Table III.2. Specific Selection Criteria for an Offensive Mode versus a Defensive Mode (Dichotomy A-III)

General Criteria	Conditions Favoring Selection of:	
	Offensive Mode	Defensive Mode
1. Cultural set	—Oriented to gaining comparative advantage over competition and expanding market share by introducing new products.	—Oriented to consolidating gains by repelling or overturning competitive threats. —Tending to be conservative.
2. Internal strengths and weaknesses	— <i>Strengths</i> : Aggressive, risk-prone, innovative, and financially strong; with weak competitors, low entry barriers, strong supplier support, lead users, and having unique offerings. — <i>Weaknesses</i> : Generally unable to maintain position or grow unless an offensive posture is retained.	— <i>Strengths</i> : Tending to operate error-free, financially able to fend off threats, highly cost efficient, has proprietary positions, can present entry barriers, and users incur high switching costs. — <i>Weaknesses</i> : Deriving from being unable to grow because of limited resources.
3. Environmental (competitive) opportunities/threats	— <i>Opportunities</i> : Able to develop new technologies and new products with unique features. Able to expand into new areas. Competitors are vulnerable to attack. — <i>Threats</i> : Market isn't receptive to the status quo.	— <i>Opportunities</i> : Competitors become cost-inefficient.—Competitors are unable to sustain an offensive mode because of some structural deficiency (as from a maturing industry). — <i>Threats</i> : Competitors are successfully expanding.
4. Prior track-record	—Demonstrated excellence in developing new areas.	—Able to survive, even grow using defensive postures.
5. Sustainability	—Durability requires continuous innovation.	—Durability requires periodic consolidation.

Perhaps, good analogies of such dynamics lie in the field of sports such as football, basketball, tennis, etc. Winning requires a strong offense, but also an effective defense to forestall competition. That is also true in the field of business. Organizations have an important need to defend their positions against encroachment by competitors, especially in areas that relate to core technologies and businesses. Competitors are more likely to attack if a business area is attractive and vulnerabilities exist. Good defenses arise from a number of actions, including, holding proprietary positions (through patents and trade secrets), sustaining cost leadership, manufacturing expertise, providing excellent service, and generally caring for customers' needs.

Threats can also arise from environmental sectors. Organizations must continuously operate in ways that ensure consistency with the legal and regulatory environment. One effective way to do that is to not only comply with all requirements, but to aggressively seek out new marketing opportunities by assuming proactive environmental strategies (Steger, 1990). Organizations have to be persistently vigilant in defending their domains. They must constantly compare or benchmark their performance and potentialities against their competitors in order to stay on top of situations (Pryor, 1989). To a large extent, all aspects of operations become part of the defensive game. That includes building corporate value, managing long-term growth, and providing attractive returns to investors (Kuhn, 1989; Cooper, 1989). Both offensive and defensive strategies must be brought into focus at various points in time.

Risk-Embracing versus Risk-Avoiding Strategy

In general, innovating organizations tend to take on more risk than those organizations which are not committed to innovation. However, there are occasions when an organization should be less oriented toward assuming risk (Table 3). Such situations arise when an organization needs to consolidate prior gains, when resources need to be conserved, when the environment for high risk becomes hostile, and when conditions of very high ambiguity exist in the environment. However, the situation is complex. Conservative decision making in dynamic environments may actually be "riskier" since more daring positions might be more likely to yield success. Accordingly, the level of risk that is assumed depends on factors inside and outside the organization and is highly time-dependent.

Researchers such as Utterback and colleagues (1992, p. 36) have emphasized "that successful ventures require lasting commitment and persistence." Management and the researchers who are involved must be able and willing to commit significant resources to support new ventures even when uncertainty exists. The adoption of higher levels of risk is considered to be an inherent aspect of organizations which are strategically committed to innovation (Brown, 1992). Marketing research and astuteness in technological forecasting can reduce the uncertainty and make the risk more manageable, but such tactics are based on projections from past or present information.

It is frequently the case that during the course of a radical innovation, a new market has to be developed along with the innovation. This creates an interesting paradox. Radical innovations invoke high levels of risk; yet the more radical the innovation, the more likely that it will be accepted when it meets the emerging needs of the consuming public. A kind of celebrity status may be obtained. Some argue convincingly that "riskier" R&D

Table III.3. Specific Selection Criteria for a Risk-Embracing Strategy versus a Risk-Aversive Strategy (Dichotomy A-V)

<i>General Criteria</i>	<i>Conditions Favoring Selection of:</i>	
	<i>Embracing Risk</i>	<i>Avoiding Risk</i>
1. Current root strategy and need for change	—Strategies of growth through diversification and innovation are successful.	—Diversification strategy is depleting resources, suggesting a need to be more conservative.
2. Risk/benefit analysis outcomes	—Promise of high profits or increased market share exceeds risks that might be incurred. —Able to manage projected scenarios of an expansive mode.	—Perceived risks from losses or diminished market share exceed benefits of future gains. —Not able to manage perceived scenarios while assuming risks.
3. Capital available	—Cash reserves and capital are convertible to liquid assets are sufficient to manage potential downsides, and current debt ratios are not excessive.	—Capital available is limited so only modest, easily sustainable efforts can be pursued. —Exposures must be limited to strengthen a weak position.
4. Compatibility with key players	—Key players and decision makers are oriented toward assuming risks, given the prospects for success.	—A conservative, risk averse culture is operating. —Recent results argue against assuming risks.
5. Sustainability of risk posture	—Player's resources and talents are such that risk-oriented positions can be maintained. —A "technology push" strategy (pioneering new products) can be sustained.	—Limited resources, including limited expertise, do not support optimism, long term. —A "marketing pull" strategy (meeting customer needs) can be sustained.

projects are better than "safer" ones because the riskier projects will yield much higher "payoffs" if they are successful (Morris, Teisberg, & Kolbe, 1991, p. 35).

The assumption of higher risk levels arises from various projections, for example, from the likelihood of success and the perceived benefits that are anticipated. The propensity toward risk is also embedded in an organization's culture (Sitkin & Pablo, 1992). Attitudes about risk depend on levels of confidence which in turn depend on the skill levels that groups and individuals have. If an individual strongly feels that he or she can accomplish something, then they will feel that there is a lower risk level than do those who do not have that skill or confidence. That kind of thinking is especially evident among technical professionals, including the CTO. In such cases, individuals are willing to commit to accomplishing seemingly risk-laden tasks because they are highly confident that they can "pull it off." Such situations are consistent with the findings of Cooper

(1981, p. 47) who found that perceived levels of risk in new product development are highly dependent on factors that determine the "amounts at stake." In seemingly tenuous situations involving radical innovation, if little is perceived to be at stake because of abilities, resources, track record, etc., the level of perceived risk may be quite low. In one study, R&D managers were paradoxically found to be "risk averters," yet they were engaged in projects that had fairly high levels of associated risk and uncertainty (Baillie, 1980, p. 20). Technically-oriented individuals are able to control risk through various practices, including conservatism and rigor. Entrepreneurship may seem to be a risky endeavor; but entrepreneurs do *not* gamble recklessly (Drucker, 1985, pp. 28-29, 128-129). They tend to be studied and analytical, sometimes intuitive, measuring carefully before acting, so that chances for success are maximized. Successful entrepreneurs and new venture managers tend to be willing risk takers, but also rank high in managerial ability (Timmons, Smollen, & Dingee, 1985). *Measured risk taking* is a natural pattern of action among entrepreneurs.

There may be more risk perceived if individuals reject an exciting opportunity that they feel others might accomplish first. As a result, individuals, as well as the organizations involved, may expend substantially higher levels of effort than might normally be the case. Under threats of being preempted, a kind of *paranoia* can arise which leads individuals to be unusually motivated to achieve positive results.

Internal versus External Focus

Table III.4 gives criteria for choosing between an internal focus or an external focus. When operating through an internal focus, organizations employ their own resources, including R&D, in developing new technologies. Those technologies form the basis for new products and processes. Proprietary positions are derived along with the building of new core capabilities. On the other hand, an external focus is involved when organizations build relationships and acquire needed materials, technologies, or access to markets from other organizations. The decision to develop internally or to acquire externally is related to the "make or buy" decision. Make or buy decisions can be driven by strategic considerations to gain competitive advantage or by the cultural predilections of operating managers (Buchowicz, 1991).

When organizations pursue external sources, there is the potential among technical individuals for a "not-invented-here" attitude to enter the decision process. Individuals may feel "challenged" by decisions to go outside and therefore resist them. Indeed, even though unintended, such "challenges" may be perceived as threats and accordingly may spur technical individuals to greater efforts—efforts which can be highly rewarding. In such situations,

Table III.4. Specific Selection Criteria for an Internal Focus versus an External Focus (Dichotomy A-VI)*

<i>General Criteria</i>	<i>Conditions Favoring Selection of:</i>	
	<i>Growing from Within</i>	<i>Use of External Sources</i>
1. Capabilities for internal development	—Having a significant R&D component and adequate resources. —R&D has breadth of expertise and learning ability, that is, competent individuals who can move into new technological areas.	—Inability to sustain a significant R&D effort. —R&D is limited to its current core technologies, but needs arise to penetrate into new areas where expertise is nil.
2. Availability of external resources and technologies	—Technologies sought are radical and new, not at all available externally.	—A primary source of the new technology exists which is compatible and attractive.
3. Funding availability	—Capability exists for funding for continuous growth to increase the technical base.	—Organization is cash-rich and able to buy new assets and new technologies.
4. Compatibility of partners	—Potential partners have differing interests, incompatible cultures and technologies, and timing is inappropriate.	—“Quid pro quo” aspects are mutually beneficial. Drawbacks are modest. A strategic alliance facilitates market penetration.*
5. Competitive needs	—Organization gains competitive advantage from proprietary technologies, has long lead-times and there is little threat of being preempted.	—Competitors are gaining market share in targeted areas before organization can respond with internal developments. An immediate response is needed.

Note: * An organization can look externally when it needs technologies, raw materials, products or processes that are alien to its core capabilities, when it has all or most of the technologies it needs but seeks a strategic alliance to expedite market entry, or when it needs some combination of the two.

management needs to be careful to avoid overreactions (Venkatesan, 1992). Ideally the need to outsource should be recognized and accepted by all relevant constituencies.

The strategy of securing technology externally, the process of *externalization*, has some important advantages. For example, opportunities may be provided for avoiding some of the risks of innovation, particularly when considerable time and expense must be invested to develop the expertise internally (Child, 1987). Added sales from acquisitions can yield capital for investment in the organization's own R&D and therefore produce leverage for future growth (Granstrand, et al., 1992). Reduction of time to commercialization is often the main advantage of an external technology acquisition strategy, but it is not achieved without substantial risk or the possibility of low returns (Robertson, 1992, p. 29).

A focus on *internalization* or internal technology development is commonly associated with organizations that are highly committed to leadership through technological innovation. In the process of doing that, the organization is not only building an important basic position in new technology (products/processes), it is building the organization itself, its R&D, and its capability for achieving future innovations which are technologically important. The ability to develop distinctive technical know-how and to be able to maintain, nurture, and extend that know-how into new areas, represents the building of "imbedded technology capabilities" (Rubenstein, 1989, p. 356). Others, over time, have referred to similar concepts as distinctive competencies, core capabilities, etc.; so it is a well-recognized concept (Leonard-Barton, 1992). Core capabilities have been defined as "a set of differentiated skills, organizational routines, and specific assets that underlie competitive advantage" (Hamilton & Singh, 1992, p. 14). According to Leonard-Barton (1992, p. 111), the "capabilities are considered *core* if they differentiate a company strategically." Core capabilities frequently arise from *internal R&D*. Evolving technologies have usually been protected through patents as intellectual property. A great multitude of distinguished firms, for example, Du Pont, 3M, GE, Motorola, Monsanto, P&G, IBM, Apple Computer, Intel, Genentech, etc., have emerged and become preeminent by internally cultivating core technologies.

Adaptability, renewal, and creation of new capabilities are necessary elements in maintaining the essential meaning of core capability in innovating organizations (Brown, 1991; Hamilton & Singh, 1992; Mezias & Glynn, 1993). If organizations ignore this need for renewal, long term, they may eventually succumb to obsolescence. That decline would be hastened if the organizations are operating with limited proprietary positions in dynamic environments. Operating environments are becoming increasingly more dynamic with the passage of time. Proprietary positions are also more and more difficult to hold because of increasing competitiveness, worldwide. The need for a strategy of constant renewal has been eloquently stated in the literature (Levitt, 1988; Brown, 1991).

While new capabilities evolve from culture, Leonard-Barton (1992, p. 111) notes that there can be downsides to core capabilities that become inappropriate, and termed these "core rigidities." Along related lines, McDonough and Barczak (1991) found that the embraced style of leadership within an organization can influence speed of development more than the purely objective considerations of whether internal or external sourcing of new technology should be pursued. The innovating organization and its CTO need to be mindful of these factors so that an appropriate, objective balance can be obtained when choosing between internal and external sources.

Perspectives from Managers of Innovation

Interview with George E. Pake, Former Vice President of Research and Development Xerox Corporation, Palo Alto Research Center (PARC), and Director Emeritus of the Institute for Research on Learning

Dr. Pake: First, a little background on me. I was hired by Xerox with the specific assignment to start a new research center. The group vice president, Dr. Jack Goldman, hired me. Dr. Goldman and the chairman, Mr. C.P. McColough, wanted a new location for Xerox R&D, one which would be close to a major university. At the time, there was a corporate R&D facility in Rochester, New York, near headquarters. So Dr. Goldman and I went up and down the West Coast looking for an appropriate location. In 1969-1970, large portions of Stanford land were undeveloped at Palo Alto. The region was not yet called Silicon Valley, but Hewlett-Packard, Varian, and Fairchild Semiconductor were already there, next to Stanford University. Stanford owned and leased the property.

Palo Alto was familiar territory for me. I was a professor of physics at Stanford from 1956-1962. Mr. McColough wanted strong relations with a university and I had insights to that. He also wanted a person with experience in research administration. I had served as an administrator in the academic field, but also had some early industrial research experience. Although I was a research physicist, imaging technology was not my discipline at the time. I also needed to gain familiarity with computer science and with digital technology since our management wanted us to move forward from our base in analogue technology. So, I had some feelings of insecurity in starting the job at Xerox. But I overcame those feelings by starting with an aggressive strategy in recruiting. I felt it was important to get first-rate people and to give them the best possible environment to work in. I traveled across the country seeking candidates. So I was personally

involved with recruiting the first management cadre at PARC. Recruiting was done at the best computer science departments: at MIT, Carnegie-Mellon, and at Stanford. I went to those departments and asked who are the best people, and which are the most interesting research projects. Lists evolved from which the best people were interviewed and selected. We also were able to recruit some of the best minds in industry. Our timing was good. In 1971-72, there was a little recession so there were companies in Chapter 11. Some top people were available. I "swooped like a big bird and got them on a rebound." One of the individuals we recruited in the 1970s was Dr. John Seely Brown who headed up our artificial intelligence program. He is now [1992] vice president of advanced research at PARC.

So, in developing an effective program of technical creativity, the first ingredient is to recruit the best people. The second important element is to give them the best equipment and the best environment. The third component is to make sure that the R&D work answers the needs and fits with the strategies of the corporation.

By having the best environment, I mean having an open environment and one which is linked with university activities and research, most notably for us at Stanford. It is also important to have an atmosphere of pluralism, one which encourages the interaction of different perspectives.

There were very few constraints that I can think of in these efforts. We were able at the outset to set the tone for what we wanted to do. I visited the new company headquarters and met with Mr. McColough and asked what are your research needs? There was an early issue relating to short versus long-range research. I was concerned about the time horizon for doing meaningful research. I said you won't get anything of importance within five years. I felt that something like a 5-10 year lead-time was required. My thinking had evolved from my earlier experience at Westinghouse. Mr. McColough agreed with the 5-10 year time frame.

We began with three laboratories: computer science (an interdisciplinary effort), physical science (integrated circuits and solid state lasers), and systems science (an applied R&D laboratory). So, we bridged from basic research to applied research within one R&D facility. As a transplanted academic, I recognized that success in applied R&D requires an understanding of basic scientific principles, and vice versa. I think it is a mistake to build barriers between these perspectives.

Another early issue was what projects should we work on? I was not an expert in the field; so I convened our staff scientists in various groups and asked individuals to develop position papers on emerging technologies, areas that they felt were important to work on. In a sense, these individuals were doing the technological forecasting. They were projecting technology to the future. It was a bottom-up approach. They responded well on that. The papers were discussed and reviewed in evolving our first research plan.

Throughout these planning sessions, we were aware of the center's mission in technology. Mr. McColough had asked that we "devise and develop the architecture of information in the business office." That mission became our "Holy Grail." Whenever I hired new individuals into the center, I emphasized that goal. As a result, we thought in terms of integrating systems. We married copying technology with digital technology—in combination to create laser printing. The goal of office information architecture was an important agenda item in the technology forecasting papers that came from our staff. We were able to connect our notions on technology with what Xerox should be doing. So, when we projected our research plan to top management, we got approval and funding. At the time, the company was cash rich so monies were available for investment in R&D. Actually the fact that the company had been so successful, up to the point at which I joined them, created a modest problem. I had to motivate individuals to

still greater effort. As I have said, that problem was solved by bringing in new top people who were highly motivated to be successful.

The planning effort, which I have described, had become a way of life at the center. In the spring of each year, we wrote a five-year plan, and each fall, we wrote a two-year forward plan. So, we were always involved with planning. Managers and key researchers were involved with these efforts.

Interviewer: Considering the flow of technology, I have heard and read that our nation has lost ground in the ability to create new scientific advances. We, of course, have in the first part of our century been incredibly productive, with many accomplishments emerging, such as transistors, lasers, integrated circuits, and many others. Have we lost or are we losing our ability to create significant new technologies?

Dr. Pake: I have the impression that we are not as good as we once were. I fear that we have lost ground, but I'm not as much in touch as I was before my retirement. With the splitting off of Bellcore, Bell Labs is smaller and may not be as good. GE may not be as good as they once were in basic research.

Interviewer: Are the Japanese beginning to become competitive in this regard? I have heard they are making a major effort to learn how to be creative? Isn't the ultimate weapon in competitiveness our ability to create completely new science and technology?

Dr. Pake: Yes, that is so. But, in Japan the greatest excellence is in the applied area. In the 1980s, I went to Fuji Xerox and also visited Hitachi, NEC and other Japanese firms. I was able to chat with the Japanese on the subject of research. The Japanese take a longer view of the applied area. They also have more respect for executives responsible for research. When I visited Hitachi and NEC, the chief executive officer, an engineer, came out to greet me. The CEOs I met were technically trained.

I have a theory about a possible barrier to technical creativity, a barrier of major importance. There are too many managers in the U.S. who have

no technical knowledge. I'm talking about the CEO or high level managers. Typically the R&D person is technical but must deal with non-technical managers. Perspectives differ. Criteria for making decisions derive from different contexts. So, communications gaps can arise.

At Xerox, I was fortunate. The chairman, Peter McColough, was a lawyer, but he had an undergraduate degree in chemistry. There are some signs that the situation in the U.S. may be improving. At General Motors, the top person is an engineer. And Bell Labs is headed by a major scientist. Also, the chemical industry and the semiconductor industry have done a better job in this regard, by having technical individuals participate strongly in top management. But the participation is not that wide-spread throughout the U.S. This is my pet theory for why the U.S. is not doing as well as it might.

Interviewer: Isn't there a counter argument in this regard, which suggests that technical managers may be too tunnel-visioned, and not sufficiently up on the business side of management?

Dr. Pake: Yes, there is that counter argument. But, I think that issue makes it especially important for scientists and engineers, especially in industry, to develop business knowledge. There is another aspect too: The CEO need not have a detailed understanding of the science or technology, but should understand the time required for completing technical developments. At Hitachi, the long time horizon is very important, and persons managing the firm are steeped in technology. On the other hand, the time horizons may be longer in the U.S. than is actually realized. I kept accurate records of time-to-market at Xerox, and evolved histograms. An average of seven years, from the beginning of research to market introduction, was evident for significant developments.

As far as creativity is concerned, I have been very interested in that subject since retiring from Xerox. I headed the Institute for Research on Learning at Palo Alto. That institute grew out of

the artificial intelligence activity at Xerox and is substantially funded by Xerox. Now, I am director emeritus of the institute. We know very little about the process of creativity, particularly the neurobiological processes that might be involved. But, we have made some practical advances. For example, we have conducted some interesting studies at middle schools, at junior high schools. We have found that by tapping inner resources early, by turning individuals loose, by giving freedom and encouragement, we can make major improvements in the ability to be creative.

Interview with Darleane C. Hoffman, Professor, University of California, Berkeley, and Lawrence Berkeley National Laboratories

Professor Hoffman: In facilitating technical creativity, it is important to have a stable environment, and one in which the necessary tools are available. You also have to have freedom, especially in conducting fundamental research, where you have to be able to explore different approaches. And even in applied research, given a problem, professionals should have the freedom to address the problem in a fundamental way. If you're guiding individuals, you should not tell them how to solve a problem.

I have eight graduate students working towards their Ph.D. degrees. They first have to know the literature—what others have done. Some say that stifles creativity. Some say it's bad to be influenced by others. I disagree. I feel it is very important to know what others have thought and done. That knowledge provides a sound foundation for moving forward.

I am now a tenured full professor of chemistry at U.C.-Berkeley. I came into the department with tenure seven years ago. Tenure was given up-front because of my credentials. This was an honor because, at Cal-Berkeley, a professor has to develop a subfield of chemistry in order to get tenure. The chemistry department at Cal-Berkeley is quite large, numbering some 55 faculty. Each faculty member is more or less

autonomous, so this has been a very nice appointment. I have a joint appointment, one with U.C.-Berkeley and one with the Lawrence Berkeley laboratory. Both institutions wanted a leader of nuclear chemistry. I had served earlier as a division leader at Los Alamos, where I headed a division of about 160 people. Given that Los Alamos is part of DOE, as is Lawrence Berkeley, I now have 38 years of continuous service. When I joined this facility, Professor Glenn Seaborg was no longer taking students. So, I met the needs of both institutions, which wanted to keep their nuclear programs going, and going strongly. Few universities offer nuclear chemistry. Fewer still offer transactinide chemistry, which is my area of interest. I was also very interested in developing Ph.D. students. It was a big step for me. I had broad experience in management, which I like, as well as in research, but no experience as a professor. So, I went from the environment of a research institution to an academic environment. During the first semester, I taught a lab course and had very little in the way of modern equipment. It was really challenging—but rewarding. Students interviewed me. They liked me and were interested in my area of research. Advising and directing the research of Ph.D. students has been very satisfying for me.

Interviewer: With this interesting background of being a teacher, a researcher, and a manager, can you give some further insights on what you feel helps individuals to be creative?

Professor Hoffman: Rewards are important. With scientists, rewards are two things: First, doing science itself, without too many constraints; that is a reward. Nowadays, there are more constraints. We encounter many restrictions from EH&S (Environmental Health and Safety). Many of these constraints are necessary and useful, but there are so many more to cope with than in earlier times. And being both a chemist and a nuclear chemist as well, sometimes makes me feel like I'm getting "a double whammy." We attend many meetings on this subject and there are many

follow-ups. So, given that these constraints are important, we feel rewarded in a sense, when we can continue to scientifically explore this important field.

Another important aspect is that the system (the organization) needs to allow people to develop professionally. By that I include allowing scientists to continue in a research area for a reasonable period so they can make a significant contribution. You can't just switch people around like pegs. It is also important to recognize that really good scientists could and would branch out into many fields. They really enjoy opportunities to expand their thinking. So, going to meetings, and interacting with other professionals, are important elements of reward or encouragement.

Of course, for all of this, I am assuming that most organizations have acceptable policies for salary and promotion, which are also important. Endless restrictions, having a narrow focus, having to deal with a bureaucracy, all are inhibiting to creativity. But, even with that notion, there has to be some structure and some guidance operating in the system. For example, I met with various group leaders at Los Alamos, when I was division leader, so my colleagues and I would know what each were doing. We wanted to know where we were heading and where we wanted to go, on the short and long term. Even now, as a professor, I have to plan and be entrepreneurial to make sure that our funding levels are maintained.

I have been very fortunate in my career to be associated with excellent people at all levels. Excellent people were available who were interested in trying different things. This made it easy for me to manage. I was able, because of their excellence, to meet their needs for more autonomy. But again, as manager, you have to impose some guidance. You have to have some vision of "what you are, why you are," and so on. And scientists, themselves, recognize the need for relevance. They want to see that what they are doing is potentially important.

In this discussion, I've talked more about people who are pretty advanced as scientists, who can make important contributions. We are dealing mostly with individuals who are Ph.D.s. A good assumption about Ph.D.s is that they have to be intelligent, well organized, and highly motivated. Those qualities stay with them as their careers evolve. Those qualities are essential for achieving technical creativity.

Interviewer: Which have a greater impact on such individuals, facilitators or barriers?

Professor Hoffman: That's a tough question. If barriers are tough enough, people will give up. But, really good people will overcome tough barriers. So the answer to that question depends on the people involved. I have found that, for a fair number of people, even "benign neglect" is not bad.

Interviewer: Can you briefly describe a project, one which illustrates the nature of your experiences in the context of our discussion?

Professor Hoffman: A successful one, that comes to mind, goes way back to one of the first programs I was associated with. I was involved with a testing program at Los Alamos. We wanted to prepare heavy isotopes and separate out significant quantities of fermium-257, the heaviest known isotope of that element at that time. A few of us wanted to see what its fission properties were. Only a few tenths of a fission per minute had been isolated prior to that time. We collaborated with another group in measuring fission properties of material that we separated. Indications were that the nucleus of the atom was breaking into two equal parts so we were observing low energy symmetric fission for the first time. I remember gathering the data and going home with the flu. I was lying in bed going over the data. I sensed that we had made this discovery and the data indicated we had. It was an "Eureka experience." When I went back to the lab, we verified the results. It was an exciting experience.

In contrast to that experience, it can be very frustrating if you have a group, and need to

collaborate with others, and one group doesn't work sufficiently hard to be ready with what is needed. Even graduate students have responsibilities to support the work of others. When there are shortfalls, it is very frustrating. When I'm engaged in large collaborations, I tend to be "a worry wart." I try to make sure that things get done on time. All of this can be even more frustrating when we also have to deal with the high levels of regulation which limit research.

These are the kinds of challenges that make research exciting, and especially so when the work is ultimately successful.

Interview with Keith W. McHenry, Senior Vice President, AMOCO Corporation

Interviewer: Can you describe a program that illustrates your involvement with new technology development? What comes to mind?

Dr. McHenry: Back in the 1960s, there was a revolution in the catalyst used for catalytic cracking of petroleum feedstocks. We at Amoco Oil R&D were very much involved with that effort through the implementation phase. We characterized the catalyst and various products in a mathematical way, using chemical engineering principles. With my background in chemical engineering, I was able to be involved in the mathematical modeling. The program came at an opportune time for our company and for our industry. It led to a host of useful refined products at a time when the quality of those products was rapidly improving. It was very satisfying because, with so many useful products, we were able to contribute strongly to the earnings of the company. The new approach in catalytic cracking was a critical concept. We learned how to treat a key processing parameter that worked and yielded substantial benefits in line with company objectives.

Interviewer: Based on these experiences, what do you feel enhances the ability of individuals to be technically creative, leading to significant advances in science or technology?

Dr. McHenry: First of all, people need freedom to think broadly. They need complete freedom in this regard. When I was a catalytic chemist, I needed to be able to take materials, to manipulate and test them, and to be able to see what they were good for. I needed to do these things without having to worry about limitations or constraints. So, you have to be able to follow your scientific curiosity.

But, as a counterpoint, it is important to recognize that too much "carte blanche" can be dysfunctional. In the context of industrial research, important breakthroughs come when there is a framework for pursuing a particular area. There has to be a perception of a specific application. So catalyst development chemists need to have specific end-uses in mind. They need to be able to think, that if certain materials are treated in certain ways, then desired results for particular applications will be obtained. There must be a perception of potential end-uses. So, one needs to have some structure in order to be successful in the industrial arena.

Balance is important. By this I mean to emphasize having *both* a generation of new ideas *and* a perception of meaningful applications. One without the other goes nowhere. For example, I can recall a group of chemists who were determining the chemistry of coal. They suffered because they placed too much emphasis on applications. They were too structured in their perspective so important new ideas were not generated. It is also important to be organized, to have adequate documentation of procedures and results. A "lack of tidiness" can be very harmful. Interestingly, the person in our division who has the most patents also is one of the most organized, the most structured in approach, of all our managers. Having an appropriate balance is important.

Management also needs to contribute strongly by providing understanding and support. Tools have to be available to provide opportunities for coming up with new ideas. By tools, I

mean to include equipment, physical resources, an appropriate institutional setting. You have to have technical resources as well as management resources. An effective "dual ladder system" is an important element within the portfolio of resources.

Individuals also need to receive recognition for their contributions. Such recognition should be available from both peers and from "the system." I'm including in this category promotions, handshakes, and even opportunities for publications and professional development.

Interviewer: Can you train individuals to be creative?

Dr. McHenry: I believe that creative people are born and not made. So, the creative ability of the individual is a primary prerequisite for all that we have discussed to this point. But, an individual's creativity is enhanced and made relevant by how the organization manages R&D. The enhancement includes training and what we discussed earlier.

I have considered management's responsibility in relation to organizational size in a paper titled: "R&D Management Strategy—Key to Sustained Industrial Success" (McHenry, 1988). The conclusions drawn are quoted as follows:

1. Sound technology—the pride of most R&D organizations—is vital to the success of firms at all stages of growth. Start-ups and mature firms may not be broad enough to guard against outside attack. Shallow empiricism can come to mature firms over time.
2. Quick technology must be the hallmark of young firms, but if the older ones let the R&D function slow down, they can be in trouble as well.
3. Technology close to the customer is the bread and butter of the start-up firm. Barriers tend to develop as the firm matures and efficiency demands division of labor. Without customer input to technology, the older firms will fail.

4. Technology integral to company business planning is not difficult when companies are small. Too often this marriage ends as the partners age. Yet, it's equally important that older firms know how technology fits into their future.
5. Thus, when viewed across the spectrum of company maturity, the R&D management strategy leading to sustained success for the firm will not change very much.

MINICASES

Minicase III.1. Meet Competition's Existing Products or Develop New Products?

Scenario. You have just joined a relatively small firm as director of R&D (within the last six months) and have been asked to develop improved products which meet the performance of competition's products. You come from a larger, more sophisticated organization in a related industry where you had been very successful in leading product development efforts as a project manager. Your new company's products have grown old and have become deficient in light of competition. There is much pressure on you to quell criticisms from sales and the CEO and customers who feel the products are defective. You are asked repeatedly to improve various products so they are as good as competition's, and to do it quickly. You know you can improve the existing products but you also know you can create new products that are even better than competition's. Given limited resources, you can't do both. WDYD?

Discussion. The chief technology officer (CTO) has a key role to play in determining appropriate policies, that is, in strategic management, whether that role is invited or not. Frequently, in smaller firms, research managers have to make critical decisions even in a climate of criticism from other constituencies, decisions which are important for the organization, but also for the credibility of R&D. In this case, the CTO is asked to adopt a strategy which may or may not be best for the organization, long term. Given limited resources, the problem relates to the "time line" which is an important consideration in any issue. The issue that must be recognized is that while improvements are being made, the "clock" is not standing still.

Competition very likely will be developing next generation products during the same time period. An organization that is “playing catch-up” may, therefore, become frozen in a situation where it is continually behind advancing technology unless it is willing to try to “leap-frog” competition. A willingness to do that in the face of criticism takes considerable courage, but that “goes along with the territory.”

Minicase III.2. Supplier Lock-in

Scenario. You are a CEO of a micro-computer firm and have been under severe competitive pressure. Your vice president of design engineering came to you earlier and mentioned that he could save the company a lot of money by obtaining silicon chips from a new supplier. The chips were tested in the laboratory and they performed well. The supplier required an exclusive long-term arrangement with guaranteed quantities in order to provide the attractive price. Given the situation that is presented, you have very little time to decide on this question. The vice president of manufacturing objects to going with the new supplier. He says that the chip has not been fully tested, that design engineering has goofed before, and that this violates company policy of having multiple sources of raw materials. You want to save money quickly but you don't want to make a big mistake. WDYD?

Discussion. The conservative approach in this case would be to do further testing and to gain a consensus from the key individuals on what should be done. However, if time is extremely limited, then that strategy could in effect be a “no” and the option would be passed. Frequently, decisions have to be made with inadequate information. In such cases, the issue may come down to the levels of *trust* that the decision maker has in the parties involved, based on prior experience, moderated by any hedges that can be negotiated into an evolving contract with the new supplier. In other words, if a performance clause can be included, that would reduce the risk. If not, then the intangibles of trust and intuition may become the most important considerations.

Minicase III.3. Strategy in Budgeting

Scenario. You are relatively new with a company and have been asked to come up with an annual budget for your department, a newly formalized R&D department. The company is interested in new products but has not traditionally favored R&D with high levels of support. You know in your own mind that you can justify a doubling of the budget. The company is conservative on capital expenditures and has had a history of operating very “lean” on people. You feel a need to double your staff in order to achieve

the aggressive new product development program that management wants. But in hard times, the company has had to cut back R&D personnel. And you don't know if you could get your budget approved with a large increase in staff even if you requested it. WDYD?

Discussion. Within organizations, the budgetary process is an objective process that is based on analysis; but it should also be recognized that budgeting is also a political "art-form." The R&D manager needs to present a strong case based on requirements for getting the job done but also must be realistic about the realities of the situation. A budget must be presented which is reasonable given the operating constraints and the projected requirements. Being new to the organization, the manager has not had time to verify expectations with actual performance, so credibility is not entirely established. On the other hand, if the individual was brought in to advance the organization, there exists an opportunity to gain needed resources. The important thing to recognize is that one is engaged in a negotiating game with other players competing for limited resources. One potentially good strategy is to push for significant, but reasonable, increases in funding, but to be oriented to the long term in achieving those increases.

Minicase III.4. CEO Push/Pull

Scenario. You're the vice president of R&D for a personal care products firm that is marketing a line of specialty soaps for consumer use. One Monday morning, the CEO comes in and calls his key top managers in for a special conference. He says he has a great idea that must be worked on immediately. While taking a bath, he thought of a "sensational new idea for getting us into the cosmetic soap bar business." The idea was to make the product in the form of a gel in a floating tube. The product could be pumped out onto the skin as needed. As special enhancements, the tube could be made in the shape of designer forms or could be simplified shapes resembling animals for children. Each executive looked slightly aghast. You could think of five quick reasons why it would not work (high costs, stability problems, reliability problems, etc.). The CEO looks squarely at you and says: "Let's have a marketable prototype in 90 days." WDYD?

Discussion. At "first blush," the idea of the president may seem absurd, but one must assume that the CEO has had a strong record of success to have been able to attain that position. The CEO's intuition may, therefore, be reliable in this case. Along with that, the question arises as to how prudent it might be to summarily reject a CEO's suggestion in a public forum even if there are doubts. Some leaders invite critical debate, even emphasize its importance as a means for strengthening the reliability of emerging

decisions. Others, in effect, discourage debate. In this case, it appears that the decision is a *fait accompli* and the CEO simply wants it to be carried out. On the other hand, managers have responsibility to try to avoid making bad decisions whenever possible. That is the dilemma of this case. One possible approach in this case is to accept the assignment, with expressed reservations, and to diligently pursue imposed goals, gathering and publishing data which test the premises made so the viability of the product becomes clear.

Minicase III.5. Out! Out! Damned Label

Scenario. You are the vice president of operations and have been called upon to serve as an expert witness in a product liability suit involving one of your company's products. The damages requested by the plaintiff are rather large, amounting to more than one million dollars, and you have felt a lot of pressure to avoid a negative judgment. The suit involved a claim of severe injury and the allegation that the product was defective, either in formula or in manufacture. You have reviewed the files and have tested retain samples of the product and all appears to be in good order. You did, however, find that the label used for the product was somewhat unclear, depending on interpretation, in directions for use. After you joined the company, that label was improved so that a clearer label is now in use. You are flying to Kansas City to meet with your company's attorney for a pretrial conference. You wonder if you should "open Pandora's Box" or "be cool?" WDYD?

Discussion. It is not uncommon for technical individuals to serve as expert witnesses in litigations involving products of their organizations. Law suits involving difficult product liability issues require a lot of preparation and thought, especially when the issues are not clear-cut, as is frequently the case. An executive generally feels motivated to support the interests of the organization, yet must operate within the bounds of what is ethical and reasonable, given the availability of science-based data. In this case, a potentially damaging question was discovered which should be brought to the attention of the organization's advocate. Based on open discussion, possible strategies can be discussed to determine how to best deal with the issue should it arise in court. What is perceived as a potential issue by some, may not actually be regarded as a problem, given inputs of common sense. So, it is generally best to communicate such "gray areas" to avoid the possibility of unexpected surprises that may be disadvantageous to one's position. In many cases, envisioned problems do not become issues, or they are neutralized by objective analysis.

NOTES

1. See also Friar and Horwitch (1985) for an excellent discussion of technology strategy.
2. Note that Mintzberg's (1983) contributions on structural designs are also pertinent and are discussed later in the text in Chapter VIII.
3. A continuum is consistent with the notion that differing orientations and postures, operating in tandem, will frequently be encountered in organizations.
4. The italics were added by the author (Ginn) for emphasis.
5. The various tools for gathering information in planning, for example, by technology forecasting, environmental scanning, and the use of technology road maps, are well documented in excellent works (Pearce & Robinson, 1991; Higgins & Vincze, 1993; Willyard & McClees, 1987).

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CASE 2. COMDISCO DISASTER RECOVERY SERVICES INC. (CDRS): WHAT IF ...?

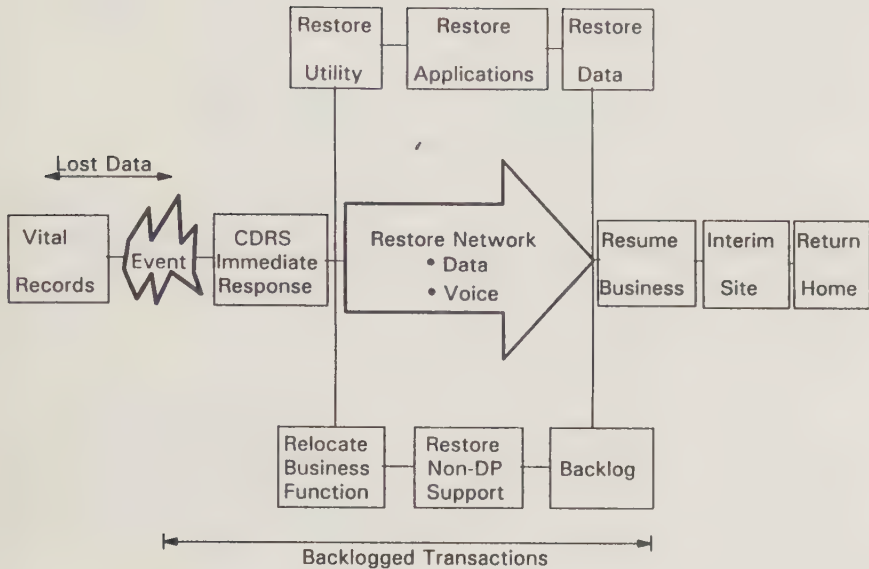
It was 5:57 a.m., April 13. The Monday morning rush hour was just beginning in Chicago. One of the earliest calls came from the Merchandise Mart. Water was pouring into basement areas. The Chicago Fire Brigade responded. What had started as seepage, perhaps weeks earlier, became a trickle, then a strong flow, and finally a deluge. A whirlpool in the Chicago River marked the spot where water was pouring down into the old coal-railway tunnel system. Basements and lower floors of major commercial buildings all over the Loop rapidly filled with water. Generators and electric power systems were submerged. The Great Chicago Flood of 1992 had begun. After more than a week of frustration in trying to stem the flow, it was observed that the city that "works" had become the city that "leaks." Work stopped in many offices because there was no electricity, no telecommunications.

A disaster had occurred for many. But for some, it was an opportunity and a need to assist customers. In responding to calls for help, Comdisco Disaster Recovery Services, Inc. (CDRS) was reported to have its busiest week in the history of the company.¹ The morning of the flood was the busiest ever with disaster declarations made by 16 subscribing companies (customers) by 1 p.m.² According to a *Chicago Tribune* article, Raymond Hipp, president of CDRS, indicated that several businesses which were not customers had to be turned away because existing customer contracts did not allow CDRS "to take on business from someone already in a disaster mode."³ CDRS responded to its customers by efficiently providing a complex of backup systems, employing well-rehearsed protocols already in place. Backup computer services were provided on CDRS's mainframes, along with workspace backup as needed, so businesses could continue critical operations without interruption.

NATURE OF CDRS OPERATIONS

CDRS was founded in 1980 as a wholly owned subsidiary of Comdisco, Inc., the world's largest independent remarketer and lessor of high technology equipment (computers and peripherals). CDRS provides disaster recovery protection and integrated business recovery solutions for situations that might prevent or impede continuity of operations. Fires, floods, and earthquakes or storms are examples of events which might threaten costly, if not fatal, interruptions of business.

The solutions provided by CDRS to its customers include: consulting services, planning software, alternate computer and end-user sites,



Source: From Comdisco Disaster Recovery Services, "The Facts About Business Continuity Planning," Pub. No. CP-F-491. Copyright Comdisco, Inc., 1991. Reprinted by permission of Comdisco, Inc.

Exhibit III.1. Business Recovery Process of CDRS⁶

network recovery, continuous availability services, and mobile modular data centers. Consulting services for contingency planning include courses and consulting on project management and recovery plan development.⁴ The Continuous Availability Product Family encompasses electronic vaulting, remote journaling, database shadowing, standby services, and facility management services.⁵ The solutions are implemented through CDRS "Hot Sites."

CDRS uses systems management in providing a Business Recovery Process (Exhibit III.1).⁶ The business continuity program is a means for protecting investments and ensuring profitability of an enterprise. A product strategy called "CDRS NET" is implemented through Computer Recovery Facilities and Business Recovery Facilities Workstations.⁷ Capabilities are provided for end-user requirements, such as terminals, PCs, voice back-up, check processing backup, etc. CDRS introduced COMROCs (Comdisco Mobile Recovery Operations Centers) which are modular units for the quick assembly of computer facilities at locations designated by users.⁸ CDRS has been instrumental in successfully handling recoveries from many disasters, including from a fire at headquarters of a major Canadian

retail chain and from a fire in the western suburbs of Chicago that interrupted telephone communications.

GROWTH OF COMDISCO AND ITS SUBSIDIARY, CDRS

CDRS and its parent company have been incredibly successful in growth of business and earnings since their beginnings. Highlights of the historical development of Comdisco, Inc., are as follows.

Comdisco, Inc., Fiscal Year History⁹

- 1969-1970 Incorporated as Computer Discount Corporation in November 1969. Officially opened for business as a broker/dealer on January 13, 1970. First year revenues were approximately \$1 million and the staff grew from one to three.
- 1971 Reincorporated in June 1971 as Comdisco, Inc. Specialized in 360/40 activity (mid-range IBM Central Processing Unit). Went public with first stock offering (over the counter) on September 9, 1971; sold 100,000 shares of common stock in a REG A public offering, at \$4.75 per share. IBM introduces the 370 series of Central processors. Revenues were \$5,370,360; earnings \$197,635. Employees: five.
- 1972 Became the largest dealer of used IBM computer equipment, carrying a full line of 360 hardware. Virtual Memory announced by IBM; used 370 equipment available for remarketing. Comdisco International Sales Corporation established. Board of directors declares two for one stock split to stockholders. Revenues were \$14,867,465; earnings \$652,097. Employees: 11.
- 1973 Specialized in leasing of 360/40 and 360/65 equipment. Raised \$2.7 million in second stock offering. Obtained first corporate office space and opened offices in New York, Atlanta, and San Francisco. Revenues were \$24,139,645; earnings \$1,149,325. Employees: 15.

- 1974 Experienced the only company loss to date; with record high interest rates supporting a speculative inventory position of 360 mainframes, Itel Corp. depressed the market with its release of \$250 million in 360 equipment. This collapse of the market caused Comdisco to write down its 360 equipment inventory. Revenues were \$28,903,323; with a loss of \$906,002. Employees: 18.
- 1975 Earnings rebounded and leasing activity began. Used equipment product line expanded to include more 370 series CPU's and peripherals. Company debt reduced by \$3 million. Revenues were \$47,400,607; earnings \$1,116,128. Employees: 25.
- 1976 370 CPU leasing activity increased to more than 50 percent of revenues. Comdisco Financial Services, Inc. (CFS) was established. Company headquarters moved to larger offices. Sales offices were opened in Texas and Minnesota. Revenues were \$84,032,633; earnings \$2,324,742. Employees: 45.
- 1977 \$100 million mark passed in revenues and assets. First quarterly dividend of \$.10 per share paid to stockholders for the second quarter of 1977. 370 peripheral equipment activity increased. Comdisco and Forsythe/McArthur formed Terminal Leasing Company, a partnership to expand market diversity through terminal product lines. 30XX models announced by IBM. Revenues were \$112,807,379; earnings \$3,179,897. Employees: 79.
- 1978 Comprehensive computerized data base of 10,000 IBM computer users developed to identify market availability trends and activity. Two stock splits declared: three for two in February and two for one in August. Cash dividends increased by a cumulative 50 percent over 1977. Special cash dividend of \$.05 per share declared in addition to regular quarterly dividend due to sharply higher fourth quarter and year-end earnings. Entered the public debt market by issuing 15-year 11 and one-half percent subordinated debentures in the amount of \$15 million. Sales offices opened in Connecticut, Florida, and

Michigan. International office opened in Paris, France. Revenues were \$153,282,265; earnings \$4,921,581. Employees: 115

- 1979 303X activity increased, 370 CPU and peripheral placement remained strong. 4300 series announced by IBM. Comdisco Technical Services, Inc. (CTS) established. Three for two stock split declared in March. Public offering of 700,000 shares of common stock made in June. Proceeds of \$10,688,402 used to retire bank debt. Offices opened in California and Massachusetts. International offices opened in West Germany and Switzerland; Miami office opened to serve Latin America. Revenues were \$225,276,000; earnings \$10,605,000. Employees: 186.
- 1980 Comdisco listed on the New York Stock Exchange in January. Marketing emphasis shifted from buy/sell to leasing. IBM announces 3081 processor. CFS exceeds \$1 billion in total lease financing since inception. Comdisco Disaster Recovery Services (CDRS) established. Cash dividend increased by 17 percent. International subsidiaries added in Belgium and the United Kingdom; Corporate headquarters moved to larger offices. Revenues were \$265,132,000; earnings \$7,114,000. Employees: 221.
- 1981 \$50 million of 13 percent convertible, subordinated debentures due 2001 were sold; proceeds used to reduce the Company's exposure to fluctuations in short-term interest rates. Five for four stock split declared and dividend increased 25 percent. CFS arranged leases valued at \$675 million as company capitalizes on the transfer of tax benefits allowed under the Economic Recovery Tax act of 1981. IBM announced the "H" series. Comdisco Transport, Inc. (CTI) established. CDRS opened Chicago-area and New Jersey recovery centers. Revenues were \$301,538,000; earnings \$15,641,000. Employees: 300.
- 1982 3033 processor and disk storage device activity increases. Lease base growth continues to be strong, especially among mid-size companies. CDRS opened a facility in

Northern California, for a total of three nationwide. Comdisco Maintenance Services, Inc. (CMS) established. Corporate Development Group formed to analyze investment opportunities. Three for two stock split declared; post split cash dividend increased 28 percent. \$50 million of 13 percent convertible Subordinated Debentures due 2001 were substantially converted after a call for redemption. Revenues were \$471,630,000; earnings \$29,377,000. Employees: 354.

1983 Moody's raised the company's bond rating to BA2. Company actively entered the peripheral and 3081/3033 markets. Lease Line Program activated. CDRS opens a recovery center in the Dallas/Fort Worth area, its fourth nationwide. CFS exceeds \$3 billion in total lease financing since inception. IBM Corporate creates IBM Credit Corp. to take over IBM's leasing activities. Comdisco Resources, Inc. established to engage in joint ventures with established partners as investors in developed and undeveloped oil and gas properties. A two for one stock split was declared and \$250 million of eight percent Convertible Subordinated Debentures due 2003 were sold. Revenues were \$543,180,000; earnings \$51,840,000. Employees: 504.

1984 Leasing activities reached record levels and the Company's customer lease base increased by 14 percent. Extensive customer education and support program started through Comline Reports and instructional video tapes. Research and development group formed to develop products for equity sales. CDRS opens "super center" in Carlstadt, New Jersey, its fifth recovery site. Comdisco Equities, Inc., a subsidiary engaging in risk arbitrage, is formed. International sales offices are opened in the United Kingdom and the Netherlands. Earnings and revenues down due to disruption of tax-advantaged transactions during a nationwide IRS review of same. In spite of difficulties, 1984 was the second highest earnings period (to date) in Comdisco's history. Revenues were \$558,388,000; earnings \$29,702,000. Employees: 643.

- 1985 Company regained its pre-1984 momentum and posted record results in all areas, with earnings per share doubling the 1984 results. During the second quarter, the company exchanged approximately 77 percent of its outstanding eight percent Convertible Subordinated Debentures for a new issue 9.65 percent Senior Subordinated Debentures. The exchange substantially reduced the future dilative effects that would have resulted from the conversion rights of the eight percent Debentures. IBM introduced and began deliveries of its 3090 series ("Sierra") Central Processing Unit. Comdisco expands its customer education program with the introduction of COMDISCO FACTS, a computer generated tool to help customers compare a Comdisco lease to other available options. CDRS becomes the largest provider of contract contingency data processing services in the country; construction begins on CDRS sites in San Ramon, California and Montreal, Canada. International sales offices are opened in Finland, Belgium, Italy, Japan, and Spain. Revenues were \$602,907,000; earnings from operations \$57,473,000. Employees: 751.
- 1986 Comdisco achieves another record year, with revenues and operating earnings growing by 50 percent and 37 percent, respectively. Moody's raised its ratings of the company's bonds. \$225 million in Senior notes was issued and credit lines were expanded. Nihon Comdisco K.K., a joint venture with leasing affiliates of five of the largest Japanese banks, was formed. Agreement was reached on the purchase of a new corporate headquarters building which will more than double the current space. CDRS increased its subscriber base by 31 percent and added new facilities in Los Angeles, Montreal, Bridgeport (Connecticut), and St. Louis. Domestic sales offices were opened in Denver, Pittsburgh, and St. Louis. An international sales office was opened in Japan. Comdisco parts division was established. Revenues were \$901,900,000; earnings from operations \$78,800,000. Employees: 930.
- 1987 Comdisco has best year in its history, setting both revenue and earnings records despite a \$22.2 million pretax loss

in the first quarter from Comdisco Equities. During the second quarter, Comdisco authorized the redemption of all of its eight percent Convertible Subordinated Debentures due 2003. The result: a \$44.1 million increase in the company's stockholder's equity, further strengthening the company's financial condition. In early June, Comdisco became the first services company ever to receive the Partners in Progress Award from Sears, Roebuck and Co.; the award is presented annually to only 75 of Sears' 10,000 suppliers. The company reached agreement with the IRS on its audit of 1983 and 1984 income tax returns. Comdisco's sales force expanded by 17 percent in FY 1987. The company entered a new market with the establishment of a venture leasing program, which combines ordinary leasing and venture capital. CDRS contributed \$10.1 million in pre-tax earnings. Firm rentals generated from remarketing were \$223.2 million. Revenues were \$1.2 billion, earnings were \$94 million. Employees: 1,108.

1988 Comdisco has all-time record revenue and earnings from continuing operations. The company also wrote an all-time record volume of new leases. The company discontinued its risk arbitrage business during the first fiscal quarter of 1988 and had a net loss of \$80 million in arbitrage activities in the first quarter. Medical equipment leasing became a new addition to Comdisco's high technology product line. The company also entered the Systems/3X minicomputer marketplace. Comdisco's sales force increased 45 percent in FY 1988. CDRS expanded domestically as well as into the international marketplace. New leases with total lease payments of \$1.8 billion, during the initial lease term, were written. Revenues were \$1.3 billion, earnings from continuing operations were \$92 million or \$2.20 per share. Employees: 1,470.

1989 Another record year for Comdisco in revenues and earnings from continuing operations. Earnings from continuing operations were up 17 percent to \$108 million, or \$2.57 per share. Revenues increased 28 percent to \$1.7 billion. Comdisco Disaster Recovery Services (CDRS) saw a revenue growth of 58 percent and

expanded worldwide in 1989, opening up operations in Canada and Europe. During 1989, Comdisco started a new high technology asset management business known as Comdisco Portfolio Asset Management (COPAM) to remarket other company's equipment portfolios on a lease basis. In May, Comdisco announced a \$170 million Eurodollar revolving credit facility, and in September Comdisco announced that they began to issue Eurodollar commercial paper. The company's bond rating from Moody's was increased from BBB to BBB+ on its senior debt and from BBB- to BBB on subordinated debt. Comdisco was newly rated by Duff & Phelps at A- for senior debt and BBB for subordinated. Record lease volume was again recorded as new leases with total lease payments of \$2.4 billion during the initial lease term were written. Employees: 1,875.

- 1990 During 1990 Comdisco wrote an all-time record volume of new leases, with total lease payments of \$2.4 billion during the initial lease term, a 23 percent increase from the prior year. Record revenues were once again achieved, increasing 15 percent to \$1.9 billion. High technology equipment leasing accounted for 53 percent of total financings in 1990 versus 37 percent in 1989. Because the company experienced a decline in earnings from continuing operations of 21 percent. Because of temporary user uncertainty over major mainframe product announcements, the company had lower earnings contributions from the remarketing of existing mainframes. Comdisco Disaster Recovery System (CDRS) had record revenue growth of 36 percent to \$14 million. Pretax earnings for CDRS grew by 75 percent to \$14 million. CDRS served 27 customers in disaster recovery conditions in 1990. The company formed a 50 joint venture with Nomura, Babcock & Brown in March of 1990 to assist in the development of its oil and gas prospects and technology. Revenues: \$1.9 billion. Earnings from continuing operations: \$85 million, total assets: \$4.8 billion, Stockholders equity: \$589 million. Employees: 1,962.

Comdisco began in 1969-1970 with revenues of approximately \$1 million and a staff of one to three. By 1990, Comdisco's revenues and earnings

grown to \$1.9 billion and \$85 million, respectively, and the number of employees was approaching 2,000. CDRS also experienced rapid growth. By 1990, just ten years after its formation, CDRS had achieved revenues of \$118 million and pretax earnings of \$14 million. In 1991, revenues of CDRS increased by 27 percent to \$150 million while pretax earnings grew 29 percent to \$18 million.¹⁰ CDRS's operations continued to be expanded, domestically, in Europe and in the Pacific Rim. The rapid growth of Comdisco is especially extraordinary considering the small number of employees in relation to its revenues. In that regard, the company is widely recognized for its high productivity.

In the 1991 annual report, the total company (Comdisco) reported revenues of \$2.174 billion and pretax earnings of \$69 million.¹⁰ In his letter to the stockholders (p. 2), Kenneth N. Pontikes (chairman of the board and president) noted that, "for the first time, the Company reached \$5 billion in assets, exceeded \$2 billion in revenues, and increased stockholders equity to more than \$600 million."

Details of the financial performance of Comdisco and its subsidiary, CDRS, are given at the end of this case.

Interviews with Top Executives

In order to tap into the *operating culture* of Comdisco, interviews were held with two top executives: Kenneth N. Pontikes, chairman of the board and president of Comdisco, Inc., and Raymond R. Hipp, president, Comdisco Disaster Recovery Services, Inc. (CDRS). The interviews were initiated in 1988 and completed in 1992.

Among other aspects, each interviewee was asked to comment on what they considered to be facilitators and barriers in the process of technical creativity and innovation.

Interview With Kenneth N. Pontikes, Founder and CEO of Comdisco, Inc.

Mr. Pontikes: Comdisco operates a service business for the "high tech environment." We provide rental equipment encompassing electronic computers and a wide variety of peripheral equipment. The main concern of our customers is obsolescence (which they want to avoid). We just announced a "new product" today (May 1, 1988) one which involves "electronic vaulting" and "missionary services." We are innovative in what we provide. We are "market makers." We make key decisions on price, availability and have to fulfill transactions. We are systems designers and provide the

critical components to render the systems operational. Product specialists are key individuals in our marketing operations.

In terms of what helps to be creative, I feel that *competence* and *knowledge* are uppermost in importance. You need to fully understand what is the problem, its cause and effect. You need to know exactly what it is you're trying to accomplish, and why, and how the solution fits with other aspects of the business.

You need to have a *willingness to risk* and assume responsibility for that risk.

You need to have what I refer to as "*technological common sense*." By that I mean having the ability to avoid getting bogged down, not letting methodologies dominate the picture. It also means being able to attack problems that cause complexity, being able to cut through an elaborate problem and drive to a practical solution. In problem solving, it is important to be able to break down a perceived problem into smaller manageable elements, and to attack these one at a time with prioritization. By this approach one can avoid the possibility of "overcreating" or creating more complex solutions than are actually needed. People tend to strive for 100 percent—if you get to 90 percent, that frequently is 99 percent for the customer. It also requires being able to *effectively communicate*, what you are doing, what you are learning, and to do so to all concerned.

And finally, one needs to have a "strong instinct to question," an inquisitiveness, which helps you to develop the best solutions to a given problem.

As far as *barriers* to creativity and innovation are concerned, failing to attract competent people and failing to maintain an environment which stimulates, recognizes, and rewards—these are the most serious barriers.

Interview with Raymond R. Hipp, President of Comdisco Disaster Recovery Services Inc.

Mr. Hipp: CDRS is a wholly owned subsidiary of Comdisco, Inc. CDRS was formed in 1980 in order to focus on

managing recovery of information when disasters or dislocations occur. The opportunity to serve as first president of this new business was given to me by Ken Pontikes, CEO of our parent company.

The parent company, Comdisco, was founded by Ken Pontikes in 1969. Comdisco has experienced exponential growth in revenues over the ten years since its inception by managing a computer rental service world-wide. The operating culture throughout Comdisco is highly entrepreneurial and calculatedly risk-oriented.

This new post was a great opportunity for me and seemed to fit my background. My education and training has been in business administration (BA at University of Missouri and postgraduate work at both Washington University and Stanford). I worked for IBM in sales and marketing for 13 years and was general manager of Midwest Operations just prior to joining CDRS. I learned that coming from an extremely large (highly structured) organization to a relatively small entrepreneurial organization is a difficult transition. But the "beauty of Comdisco" is that Ken Pontikes is a very good judge of people. He delegates responsibility and expects you to do the job. He "doesn't nurse-maid you."

When I came over here, I met with Ken. He showed me the articles of incorporation and said "let's start the business." He wanted me to start it and get us into the disaster recovery business. So naturally, I built a business plan and took it to Ken. He said: "Fine/OK, but lets avoid overanalysis and paralysis. Let's get in, let's learn and get on with it." We designed our facility, our hardware, our advertising and marketing, and our collaterals. We found that our particular cell (our SBU) was totally different in comparison with the parent company. We learned that different services require different operating strategies, and along with that a different infrastructure.

Back in 1985 when our infrastructure was being formed, we were called upon to handle a disaster in Canada. There had been a big fire at a large multibillion dollar company and their computer went down. There was a lot riding on the situation because

it involved such a large company. It was our first major test. Although we had trained and practiced, like football players, we were not sure until "Super Bowl Day" had arrived that we would pass the test. We handled the challenge and saved the business of the company. It was difficult. We had to get data back-and-forth to another country. We had to deal with the Canadian government on various issues. I was personally involved. We flew people in. We had the company operating within 24 hours. We linked the entire network of the company into our northeastern U.S. operation. Decisions had to be made "on-line" [real time]. Because of concerns, the Canadian union members at the company threatened to quit, but that blew over. There was a lot of stress but we handled it (professionally).

The Canadian experience proved that we could manage disasters, that we, a third party can come in and "save the day." We learned well. As of 1989, we have successfully handled over 18 disasters. We are the world leader in this business. Our capabilities and services are being sought out by other countries.

Interviewer: Being as successful as you have been in your service business, can you share some insights on what facilitates technical creativity, effective problem solving, and innovation?

Mr. Hipp: First of all you need people with intelligence and judgment. Our business is very complex. We need smart people who are able to learn and solve problems. You need visionaries such as we have in our top management team. You need to understand where you are, who you are, where you are going, and where your particular niche is.

You need *planning* and *structure*. Strategic planning and tactical planning are both important. A "frame of reference" is important. Our mission today is computer back-up services. We are in the consulting business—big! We just need to focus our energies on our core business and avoid spreading ourselves too thin. We have used strengths/weaknesses analysis to good advantage, drawing upon both visionaries and practitioners in planning. We have also evolved a tactical plan which has been built on both the "revenue

side and the expense side." Plans are also developed for handling discontinuities.

With all of this, Ken (Pontikes) has continued to have an aversion to bureaucratic approaches. But both Comdisco and CDRS are growing rapidly in size. We are at \$100 million growing at a 40 percent annual rate. And Comdisco is well over \$1 billion and growing towards \$2 billion in annual revenues. So in addition to flexibility, we need discipline and infrastructure. That's why Steven Jobs had to bring in John Scully from Pepsico into Apple. We want to be entrepreneurial but at the same time build support systems for the data side of our business.

There is another trait, one which facilitates creativity and innovation, and that trait is "contention." I want debate. Decisions are not difficult if you have the right facts. We don't want "yes people." Our business demands that people tell me what they think, and without delay. We try to build it (our operating culture) so we have contention.

Another aspect that is needed is to have an *environment* which is *not overmanaged*. This requires having the right "cast of characters" (of self-motivated individuals.) Then these individuals are given the opportunity to let it happen, to be creative. We encourage them to come and join us, but when on-board we do not act as "nurse-maids."

And finally (to provide closure), you need to conduct measurements of progress and have *controls*. People need to be held accountable for performance through appraisals. Objectives should be specific. Compensation should then rest upon performance. I strongly believe in the practice of *incentive compensation* in relation to specific objectives and to company earnings.

Interviewer: Now, if you will, let's consider some barriers. What interferes with the process of technical creativity and innovation?

Mr. Hipp: Three barriers seem to me to be equally negative in their effect: overmanaging, not having good people, and not having an appropriate balancing of factors. By these I mean, first of all, in overmanaging, telling people exactly what I want them to do. That is very

self-defeating. Secondly, by failing to bring in people with skills and judgment, the potential for creativity becomes severely limited. And, finally, one needs to have an appropriate balance between "structure" and "creativity." Not having that balance represents a serious barrier.

I feel that facilitators and barriers can have an equal impact on the situation. Facilitators help to create the environment which is needed for creativity. Comdisco has a favorable environment, and is a good place to work because of the opportunities which exist. But, barriers can destroy a favorable environment. A key individual who is a "barrier generator" can destroy things overnight. That's why it's so important to bring in people who have the "right characteristics."

So in summarizing, at CDRS, we are in the business of managing discontinuities. It's an "attitudinal thing" and appropriate attitudes are very important at the top. We need to be flexible. We know we can do whatever is necessary and that we will find the way to do it (to solve the problems). The individuals who are successful in this business are "workaholics with a passion." They really care and help to create and sustain the environment needed to ensure our continuing success. They like non-intrusiveness. They want to achieve the results, and even "please the master," but be able to take pride in their *own* accomplishments.

Update with Raymond R. Hipp, June 5, 1991

Mr. Hipp: CDRS is now a ten-year-old subsidiary of a company, Comdisco, which is about 20 years old. We (CDRS) are at a "crossroads." Our growth has been strong since our beginnings. In 1991, we are at about \$160 million in sales, and we are projecting \$200 million for 1992. We are in the process of reorganizing because of opportunities, and so we can be more innovative in products and services. We are creating an "innovation committee" to get "ideas on the table." Our present organization may not encourage risk taking to a sufficient extent. We're stifling. We need to redirect our energies to better fit with the strategic plan. And we

need to be continually monitoring so we can germinate good ideas which can then be incorporated into action plans.

We have also created a CDRS advisory board from our customers to tell us how we are doing, and what is needed. The board members are a catalyst. Most of our developments arise from "marketing-pull" forces; so we regard ourselves as "system integrators" of R&D.

Interviewer: You seem to be emphasizing innovation much more now than in our earlier discussion. Why is that the case?

Mr. Hipp: Our market was forming earlier. We were second into the market and took it over. Now IBM is coming in (to disaster recovery). Now, some of our business has become "a commodity." It is difficult for us to compete on a commodity basis; so we have to "level the playing field" and do something that will overcome the maturing aspect of certain elements of our business. We have to see how we can "add value" and "repackage" to make profits better and better. So our present, new emphasis is shifting from a "high-volume" to a "high-value" perspective. We're considering a matrix management approach for organizing this activity.

We have been organized in the past according to businesses and geography. Now we'll fold the businesses back into a more functionally-oriented organization and we'll eliminate redundancies. We have to get more (performance) out of people. If we continue to level off, then we need to have people realize they will need to upscale their contributions. We have a great company, a great business. But we must change because the business is changing. We have taken stock of "our images." We redid our strategy after identifying our market, opportunities, and so on. We evolved a new road map. Now we need to organize so we can get there. And we have to be "in shape" to do it.

As a 150 million dollar company, we seemed to be "maxed out." People have been operating like they were in a 25 million dollar company. We may have to hire a couple of people from the outside in order to build a new infrastructure to run the business. We

have hit the wall already 3-4 times and had to reorganize to overcome that. Now we are "at the wall again" and have taken stock and are changing. So we are "at the crossroads."

Update with Raymond R. Hipp, February 25, 1992

Mr. Hipp: If we consider the last 11 years, CDRS has been growing at a 30-34 percent compounded rate, overall. But, when you're operating in a difficult economy, the benefits of having an effective infrastructure can become eroded. The competitive environment has become frantic. It takes tremendous effort merely to hold on to market share and keep operations running effectively. Given this environment, we are continuing our restructuring programs. We are "borrowing" from some recent thinking by George Fischer, (then) CEO of Motorola, and are emphasizing quality, functionality of product, and being the low-cost producer. Our "products" or services, the deliverable disaster-recovery systems, continue to be excellent. But when growth is extremely rapid, there is a tendency to allow extraneous elements into the system. "Fat" is created. Inefficiencies become tolerated or not even observed. Costs can escalate when growth is explosive. So, while we are fine in terms of quality and functionality, according to our customers, we now need to focus in on cost-reduction. We must get our costs down so we can compete better on a cost basis. The market perceives value but is not as willing to pay for value, as was the case earlier. It's a totally different market today that it was 5-10 years ago.

Interviewer: How have your competitors been doing in this environment?

Mr. Hipp: IBM (Business Recovery Services) and Sungard (Data Recovery Systems) are two major competitors. They are lower in cost but have not been doing well, profit-wise. We have been trimming costs all along, but will have to go to another level, and trim further. We will cut existing cost out of the system.

Interviewer: Will costs be cut through manpower reduction or by other means?

Mr. Hipp: Manpower reductions will be a major part of it. We will also include refocusing of products by culling out low volume items.

Interviewer: Your initial rapid growth came from providing effective, innovative services, and not from cost-cutting. Given that, where will your further growth come from?

Mr. Hipp: Our growth in the immediate future will be more modest than it has been. In the last few years, our growth was obtained by expanding into Europe and Asia. So now, our growth must come from internal efficiencies. We will focus on sustained quality of earnings growth. We have to be the lowest cost producer, yet add value at the same time.

Before, we were focusing almost entirely on gaining and holding market share. Now, our market share is similar to what it was before, but we have lost a couple of opportunities. Our profitability is better than it was a few months ago, and is continuing upward, but with some "bouncing around."

Given the economic environment and the competitive structure, a new strategy is essential.

Interviewer: Will you be able to grow further without innovation? Will emphasis on quality and cost-cutting be enough?

Mr. Hipp: Innovation has to be a part of it. We can't just end up selling "pots and pans." We have to keep providing integrated solutions and to expand in that capacity. We are increasing our consultative approach in providing solutions. We're now moving "up the management ladder" and are seeking ways to expand our marketplace. Before, we were strictly a "data center" in terms of what we offered. Now, we are attempting to expand from disaster recovery and business continuity to a much broader risk management perspective. Our new products will include LAN (Local Area Network) products, new consulting products, and a network alliance with MCI Communications Corporation. As we become more of a multiservice center, our risks may become greater. The "criticality" of data outside the "glass house" is greater.

These are the questions we are pondering. Given what we are about and what is happening in our environment, what should we do? How should we grow?

*Exhibit III.2. Financial Summary from 1991 Annual Report for
Comdisco, Inc. and Subsidiaries*

<i>Selected Financial Data</i>	<i>Five Year Compound Annual Growth</i>	<i>Years Ended September 30</i>	
<i>(In Millions Except Per Share Data)</i>		<i>1991</i>	<i>1990</i>
<u>Consolidated Summary of Earnings</u>			
Revenue			
Leasing	18%	\$1,633	\$1,465
Sales	9%	360	319
Disaster Recovery	39%	150	118
Other	21%	31	18
Total Revenue	17%	2,174	1,920
Costs and Expenses			
Leasing	22%	1,026	884
Sales	9%	313	279
Disaster Recovery	41%	132	104
Selling, General and Administrative	17%	201	181
Interest	11%	366	338
Total Costs and Expenses	17%	2,038	1,786
Earnings from Continuing Operations Before Income Taxes and Extraordinary Item	11%	136	134
Income Taxes			
Earnings from Continuing Operations Before Extraordinary Item	5%	83	83
Earnings (Loss) from Discontinued Operations (Net of Income Taxes)		(14)	2
Earnings Before Extraordinary Item		69	85
Extraordinary Item		—	10
Net Earnings	—	69	95
<u>Common and Common Equivalent Share Data</u>			
Earnings from Continuing Operations Before Extraordinary Item	6%	2.13	2.04
Earnings (Loss) from Discontinued Operations		(0.35)	0.05
Extraordinary Item		—	0.25
Net Earnings	—	1.78	2.34
Stockholders' Equity (Per Share)	14%	16.41	15.10
Cash Dividends Paid	13%	0.28	0.27
Average Common Shares (In Financial Position Thousands)		38,967	40,608
Total Assets	12%	\$5,006	\$4,785
Notes Payable		353	589
Total Long-term Debt		1,502	1,021

(continued)

Exhibit III.2. (Continued)

<i>(In Millions Except Per Share Data)</i>	<i>Five Year Compound Annual Growth</i>	<i>Years ended September 30</i>	
		<i>1991</i>	<i>1990</i>
Discounted Lease Rentals (Nonrecourse)		\$1,900	\$2,047
Stockholders Equity	13%	634	589
<i>Leasing Data</i>			
Total Noncancelable Rents of New Leases	7%	\$2,400	\$2,400
Future Noncancelable Lease Rentals and Disaster Recovery Subscriptions	10%	4,363	4,322

Financial Statements and Related Information

The financial condition of the Comdisco continued to be very strong and sound, although earning objectives for 1991 were not entirely realized (Exhibit III.2).¹⁰ Total assets for Comdisco reached the level of \$5.0 billion (in 1991), up from \$4.8 billion, and stockholders' equity reached \$634 million, up from \$589 million. As of September 30, 1991 (the end of fiscal 1991), Comdisco had \$1.8 billion in short-term liquidity and \$141 million in cash and cash equivalents.

In his letter to the stockholders, Kenneth H. Pontikes (chairman of the board and president of Comdisco, Inc.) noted that (p. 2):¹⁰

The goal we set for last year of overall increased earnings for fiscal 1991 was not reached. From a continuous operations basis, earnings were \$2.13 per share, up from \$2.04 last year. Unfortunately, net earnings, at \$1.78 per share, were lower than expected because of four key events: First a slowdown in the economy between IBM product cycles affected our performance. Second, the deterioration in the European Economies caused our European operations to incur a larger loss than planned. Third, our oil and gas investment suffered an after-tax, non-cash charge to earnings of \$15 million. The Board of Directors has decided it is in the best interest of the Company and its stockholders to discontinue our involvement in the business. Finally, the IBM Corporation filed suit against us in 1991. Our vigorous defense of this suit resulted in additional legal fees for the year.^{10,11}

Mr. Pontikes went on to say that "in a number of strategic areas, the Company progressed nicely in 1991." He reported that "Comdisco Disaster Recovery Services (CDRS), our largest subsidiary, continued its record of growth and profitability" (p. 3).¹⁰ In response to a question on the future of CDRS within the Comdisco family, Pontikes stated that there

was a tremendous future value for keeping CDRS and the present company together. CDRS's direction for the future will be to offer new services built around the strong nucleus present at CDRS. CDRS has enormous skills available. Those skills are both people oriented and network oriented. CDRS Net, our high capacity backbone network, is one of the most sophisticated networks in the country. In the future, CDRS and the parent company will be more closely tied together, not less. We don't divest a business that we intend to build around (pp. 6, 7).¹⁰

CDRS continued to perform strongly as reflected in the first quarter report for 1992 (ending December 31, 1991).¹² Revenues for CDRS were up for the quarter to \$42 million, compared to \$34 million for first quarter of 1991.

On March 5, 1992, the *Wall Street Journal* announced that Comdisco, Inc. was drawing charges to increase its reserves and to cover restructuring.¹³

The letter to the stockholders by Pontikes in the *1992 Annual Report of Comdisco, Inc.* (p. 6) indicated that Ray Hipp had become an executive vice president and was elected to serve as a director of the company.^{14,15}

CASE NOTES

1. Ellis Booker, "Lessons learned from the flood: Huge productivity losses point to need for broader disaster recovery plans," *Computerworld*, Software & Services Section, p. 52 (May 4, 1992).

2. Ellis Booker and Jim Nash, "Great Chicago Flood of '92: IS groups stay high and dry; Thanks to warning, business shut down systems to prepare for outage," *Computerworld*, News Section, p. 6 (April 20, 1992).

3. Jon Van, "Not just a drill for computer-backup firm," *Chicago Tribune*, pp. 1,2 (April 14, 1992).

4. *CDRS Reports*, "Contingency Services—A Unique Approach," CDRS, Rosemont, IL (April 1986).

5. *CDRS Reports*, "Continuous Availability ... Available Now!" (Spring 1989).

6. *Comdisco Disaster Recovery Services*, "The Facts About Business Continuity Planning," Pub. No. CP-F-491. (Copyright 1991, Comdisco, Inc.)

7. *CDRS Reports*, "CDRS announces Network and Facility Strategy," (winter 1990).

8. *CDRS Reports*, "CDRS Introduces COMROC," (October 1988). COMROC is a trademark of Comdisco, Inc., as is the term "Comdisco."

9. "Comdisco, Inc. Fiscal Year History" was provided by R. Hipp's office in 1991.

10. *Comdisco Inc. 1991 Annual Report*.

11. A note on contingent liabilities in the 1991 annual report for Comdisco (p. 50) details the nature of the action of IBM and IBM Credit Corporation (ICC) against Comdisco. In 1994, the case was settled between the parties.

12. *Comdisco, Inc. 1992 First Quarter Report*.

13. *Wall Street Journal*, "Comdisco Inc.: Charge is Slated to Cover Reserves and Restructuring," p. A11 (March 5, 1992).

14. *Comdisco, Inc. 1992 Annual Report*.

15. Some organizational changes, which occurred well after the writing of this case, are noted as follows. K.N. Pontikes indicated in his December 7, 1993 Letter to Stockholders (*Comdisco, Inc. 1993 Annual Report*, p. 5) that "In August, Ray Hipp elected to resign as president of Comdisco Disaster Recovery Services and as a director. Ray came to Comdisco

13 years ago to start our disaster recovery operations and he built CDRS into the World's leading business continuity provider. His contributions to Comdisco have been invaluable and we will miss his leadership and counsel."

In a news release on July 24, 1994, it was announced by the board of directors of Comdisco that "Jack Slevin, 57, has been named President and Chief Executive Officer of Comdisco, Inc., succeeding Kenneth N. Pontikes, who died on June 24, 1994. ... Commenting on the third quarter results, Slevin stated, 'We were all deeply saddened by the death of our friend and founder, Ken Pontikes. I fully intend to continue leading Comdisco on the course Ken set out for us. As our third quarter (1994) results indicate, we are a strong company, a healthy company and we embarked on exciting business opportunities. We look forward to the challenges that lie ahead.'"

In a news release dated November 8, 1994, reporting fourth quarter and 1994 year-end results, Jack Slevin, CEO, stated, "Comdisco experienced its tenth consecutive quarter of improved earnings growth" ... and noted that the "Disaster Recovery Services Division had record revenue and earnings for both the quarter and the year and this business should post record revenue and profits again in fiscal 1995."

CASE 3. ON THINKING ABOUT GREEN PRODUCTS

The early 1990s was a time of great uncertainty. The economy was weak. Consumer confidence was down. Organizations were restructuring and downsizing to improve bottom-line performance. Jobs were difficult to find—difficult to keep. International competition was fierce. The environment was difficult. The environment, itself, was an issue.

Extensive debate surrounded the issue of “Green Marketing,” the marketing of products that claimed to benefit the environment in some way or reduce negative impacts.¹ During the 1980s, a large number of products touted as being “Green” emerged in United States because of perceived marketing opportunities. While the interest by consumers in environmental issues appeared to be growing, the market for Green products was uncertain. Initially, the uncertainty also derived from the legal environment since guidelines had not as yet been published on what could be claimed and what could not be claimed. There were opportunities, but there were also threats. In the highly fluid situation that existed in the early 1990s, controversies persisted on issues of responsibility and “fuzzy” terminologies.

Although definitions were unclear and still evolving, “Green products” were frequently referred to as being “environmentally friendly.” Green products were often considered by environmentalists to be based on “natural ingredients” and packaged with materials that are biodegradable or recyclable or recycled. Besides the nature of the components involved, the concept of “Green products” have by some been extended to include other aspects, such as the nature of testing in arriving at safety claims.

Because of their high visibility, detergents and personal care products have received considerable attention from various constituencies. Labeling claims became a contentious issue among public and private sectors in the early 1990s. Various trade associations representing industry, including the CTFA (Cosmetics, Toiletries and Fragrances Association) and the SDA (Soap and Detergent Association) responded to different state regulations that were proliferating during this period.² Theodore E. Brenner, president and CEO of the SDA, provided an incisive commentary which reflected the SDA’s posture:³

Environmental Labeling Issues

By

Theodore E. Brenner

President, The Soap and Detergent Association

April 9, 1992

In recent years, the public has seen a form of labeling which sought to convince consumers that certain products are better for the environment than others. At its worst,

some of this labeling was misleading, but even more general terminology such as "environmentally friendly" offered little useful information to the purchaser.

In 1989, a coalition of environmental groups challenged the use of the term "biodegradable" in the marketing of plastic trash bags. This was a clear indication of growing public awareness of environmental labeling. Examination of those claims led to legal actions by several Attorneys General. This was the first time that potentially false or misleading *environmental* marketing claims were handled separately from the general category of false advertising. In March of 1990, a group of 10 State Attorneys General convened a "green marketing" forum in Minneapolis and later that year issued the first "Green Report." Public hearings on the report were held in San Diego in December of 1990. The outcome of these initiatives was to focus attention on what was *useful* environmental information and what was, in some instances, mere puffery.

Since that time, much of the public discussion has involved the legislative and legal aspects of environmental claims. Unfortunately, the most important aspect, the transmittal of useful environmental information to consumers, has frequently been forgotten. Without this information consumers are not able to make meaningful purchasing decisions. The more consumers understand about the true environmental qualities of the packaging and products they buy, the better equipped they will be to participate in achieving their communities' waste management goals.

Environmental Terms

Most environmental claims are marketing claims and, as such, are regulated at the national level by the Federal Trade Commission (FTC). The new dilemma faced by consumer product formulators that market their products nationwide is that a variety of specific environmental labeling regulations are cropping up on a state by state basis. Regulation of the use of environmental terms through statute or rule making has occurred or is in the process in the states of New York, Rhode Island, Maine, Wisconsin, Indiana and California. The issue is evolving in several other jurisdictions as well. This patchwork ranges from labeling standards in Maine and New York that cover the use of so-called "naked" terms, such as "recyclable" or "recycled," to the very restrictive California standards which I will discuss in a moment.

Perhaps the most perplexing among these regulations are the attempts to restrict the communication of even the most non-controversial, factual environmental information by means of labeling. For example, the recently enacted statute in California makes it a misdemeanor to truthfully label a package "Recyclable where facilities exist" unless it can be conveniently recycled in each county of over 300,000 population. This condition has no relationship to any sensible recycling, which may vary according to packaging materials and products. Newspaper, plastic and metal recycling may all be handled differently, making this county by county approach quite impractical. The law is currently being challenged in court on the grounds that this is an unconstitutional restriction of free speech. This suit has been brought by a broad coalition of advertising and manufacturing organizations.

The Federal Trade Commission, which has wide regulatory experience with respect to advertising, recognized the inherent danger of potentially misled consumers through the existence of a crazy quilt of conflicting laws and regulations. Two days of hearings were held last summer (in 1991) to determine whether or not the FTC should establish uniform federal guidelines—a move supported by the companies in the soap and detergent industry along with other industry and consumer groups and the National Association of State Attorneys General. Even more recently, the U.S. EPA held hearings in November

(1991) on the use of the terms "recycled" and "recyclable" and the familiar chasing arrows symbol in an effort to provide additional technical input to assist the FTC in its deliberations.

Although the chairman of the FTC has voiced her personal support of federal guidelines, the Commission has yet to take action. [The FTC has since issued these guidelines.]⁴ It would seem, however, to share the goals highlighted by those who testified last Summer which are to prevent consumer deception with respect to environmental claims while, at the same time, encouraging communication about environmental characteristics of products.

Conclusion

The soap and detergent industry has a long history of responsible advertising and of producing environmentally safe products. In fact, the newly popular term "biodegradable" was coined by this industry more than 30 years ago to describe how surfactants (the water-wetting and foaming ingredients in detergents) are broken down by the action of microorganisms. It was first used in connection with the introduction of new surfactants which were more readily removed in waste water treatment plants.

The last 10 years have been marked by enormous strides in solid waste management. Consumers now consider entirely new issues when purchasing their cleaning products: Should they buy a new ultra concentrate which uses less packaging? Should they choose a package with recycled content to help expand markets for recycled materials and conserve natural resources? Or, what about refillable/reusable containers?

One thing is certain, and that is that we are living in a fast changing world of expanded consumer awareness. As a responsible industry, it is our challenge to continue to provide effective and environmentally safe products and to convey factual information about these products to consumers. While not an easy task, it can be accomplished with the cooperation of government, industry and the consuming public. Our hope is that the first step will be the issuance of nationwide labeling guidelines, supported by sound, scientifically documented data, so that we can once again operate on an even playing field.⁴

Environmental Concerns and Industry Responses

The environmental movement and environmental issues have become key concerns of consumer product marketers. This awareness among marketing sectors springs from an increasing emphasis by U.S. citizens that protection of the environment has become one of the top priorities in the United States, if not in the world.¹ The United States has been spending more for pollution control than any other country. At the consumer level, significant segments of society have been willing to pay a premium for Green products. That willingness must be viewed in relation to economic considerations. Various constituencies seek to avoid extraordinary expenditures during recessionary periods. Sharp controversies can arise during such periods as to what constitute vital issues, whether they should be addressed, how should they be addressed and how one should pay for them. As an example, global warming has continued to be an environmental issue of considerable

controversy (Stevens, 1992).⁵ There are arguments and counter arguments.

Marketers of household products have responded to the environmental movement in many ways.¹ First steps have been taken to reduce packaging, to use recycled materials, and to offer concentrates which effectively reduce the package-to-product ratio in terms of usage. A broad range of companies have led the way in these endeavors, including, Procter and Gamble, Lever Brothers, Colgate-Palmolive, S.C. Johnson, Bristol-Myers, Warner Lambert, and Amway. Companies have been striving to reduce their use of paper and paper board which comprise the biggest proportion of land-fill material. To a considerable extent, there has been an emphasis on super concentrates with elimination or reduction of bulk materials.

Postscript: In 1992, the FTC published "Guides for the Use of Environmental Marketing Claims," (Commerce Clearing House, 1992, Paragraph 39,064). Updated definitions and guidelines for claims were given for such terms as: Degradable/Biodegradable/Photodegradable, Recyclable, Recycled, Recycled Content, Refillable, and so on. Examples were given of claims that were regarded as misleading as well as those not likely to be deceptive (e.g., pp. 41, 782).

FTC Environmental Guidelines (Excerpts)

As for any advertising claim, the FTC guidelines specify that any time marketers make objective environmental claims—whether explicit or implied—they must be substantiated by competent and reliable evidence. In the case of environmental claims, that evidence often will have to be competent and reliable scientific evidence.

The guides outline four other general concerns that apply to all environmental claims. These are:

1. Qualifications and disclosures should be sufficiently clear and prominent to prevent deception.
2. Environmental claims should make clear whether they apply to the product, the package, or a component of either. Claims need not be qualified with regard to minor, incidental components of the product or package.
3. Environmental claims should not overstate the environmental attribute or benefit. Marketers should avoid implying a significant environmental benefit where the benefit is, in fact, negligible.
4. A claim comparing the environmental attributes of one product with those of another product should make the basis for the comparison sufficiently clear and should be substantiated.

The FTC then went on to discuss particular environmental marketing claims and invited all interested parties to comment on the guidelines.

The soap and detergent industry has strongly focused its attention on developing products which are compatible with environment concerns. The approach taken has emphasized conservation to reduce the amount of waste entering the environment. That has been accomplished through creative design of concentrates to reduce packaging requirements and by focusing on packaging innovations that permit container reuse. Use of recycled materials and recycling also continue. So, in a very real sense, the creative energies of product development specialists have yielded opportunities for improving the environment. That effort continues.

CASE NOTES

1. For background material at the time of the "Green" debate, refer to articles by: Tom Branna, "The Environmental Movement," *HAPPI (Household and Personal Products Industries)*, pp. 51-54 (April 1991); Janet G. Herlihy, "A Return to Natural Ingredients in Color and Care," *HAPPI*, pp. 49-57 (June 1991); Anita Hippius Shaw, "Going for the Green," *Soap/Cosmetics/Chemical Specialties*, pp. 48-52 (October 1991); Angela Bellucci, "Greens and Grousers: The Roper Report," *Soap/Cosmetics/Chemical Specialties*, pp. 26-28 (November 1991); Joe Schwartz and Thomas Miller, "The Earth's Best Friends," *American Demographics*, Vol. 13, No. 2, pp. 26-35 (February 1991); Hoken Cederberg (Triple Crown America, Inc.), "Global Environmentalism and Detergents," *Soap/Cosmetics/Chemical Specialties*, pp. 48-50 (January 1992); Judann Dagnoli, "Whose Job Is It to Define Green," *Advertising Age*, Vol. 62, No. 6, 13 (February 4, 1991); and Thomas A. Hemphill, "Marketer's New Motto: It's Keen to Be Green," *Business & Society Review*, Issue 78, pp. 39-44 (summer 1991).

2. For early positions on environmental advertising at the state level, one can refer to "The Green Report," Part I (November 1990) and Part II (May 1991), issued by State Attorney General Julie Vergeront of Minnesota serving as principal author. Industry responses and background materials were graciously provided by Catherine Beckley of the Cosmetic, Toiletry, and Fragrance Association (CTFA, headquartered in Washington, D.C.) and by Janet Donahue of the Soap and Detergent Association (SDA, headquartered in New York).

3. The SDA is a national trade association composed of approximately 144 companies engaged in the formulation and marketing of soaps, detergents, and cleaning products, as well as those companies supplying products to the formulating companies. At the time of this debate, the SDA was operated under the stewardship of Theodore Brenner, president and chief executive officer. The commentary represents a speech titled "Environmental Labeling Issues," given by Theodore E. Brenner at the Soap and Detergent Association's (SDA's) videoconference on "Cleaning Products . . . In Our Homes, In Our Environment," in cooperation with the Ohio Cooperative Extension Service of Ohio State University, Columbus, Ohio (April 9, 1992). Theodore E. Brenner has since retired from the SDA after a long and illustrious career.

4. The Federal Trade Commission issued the "Guides" in the summer of 1992. These are highlighted later on in the case.

5. See W.K. Stevens' "Estimates of Warming Gain More Precision and Warn of Disaster," *The New York Times*, p. C1 (December 15, 1992).

Chapter IV

Marketing and R&D

We feel that our distinctive competence is not only our engineering skills and technology, but how we focus our efforts.

—George N. Alexy, Vice President of Marketing, Cirrus Logic, Inc.

R&D and marketing are fundamentally linked to the operations of the organization as an entrepreneurial entity. Entrepreneurship is the genesis of the marketing and R&D interaction. In this work, all relevant organizations and their members are generally operating a business, are assuming inherent risks, and very importantly are engaged in the process of innovation. The fundamental linkage between entrepreneurship and innovation was underscored by Drucker (1985, p. 30) who stated that “innovation is the specific instrument of entrepreneurship.” All kinds of innovations, social, economic, and technological, are embedded in this broad concept. Entrepreneurship consists of many themes, including: risk-taking, innovation, organizational creation, personal control, and self-esteem or achievement motivation (Bygrave, 1989; Robinson et al., 1991). Creative ability, along with having a keen business sense, have been identified as important characteristics of entrepreneurs (Timmons, Smollen, & Dingie, 1985). The blending of elements of different character, for example creativity and managerial skills, is a repeating theme in innovation.

The ability of entrepreneurs to tolerate risks over long periods of time is an interesting process which can be coupled with the invention process. Risks have to be assumed and commitments have to be made. Individuals become exposed to possible failure. The exposure itself, the desire to avoid failure, becomes a powerful source of motivation. Yet, anomalies exist. The notion of risk is subject to strong perceptions among entrepreneurs (and inventors) that, because of their abilities, they will succeed. They are calculatingly conservative in that regard.

The entrepreneurial linkage between marketing and R&D begins with the founding of the organization or firm (Feesser & Willard, 1990) and continues throughout its entire existence. Intrapreneurship involves the assumption of risk while operating within the innovating organization.

According to Pinchot (1988, p. 14), intrapreneurs "can increase the speed and cost-effectiveness of technology transfer from R&D to the marketplace." Such individuals are needed in various echelons of the innovating organization and especially in top management and in R&D and marketing.

If within the context of the organization, marketing and R&D are considered to be business segments, then the "business" of each involves the creation and introduction of new products (Ginn, 1981). Depending on the organization's operating strategy, the impetus for new products can arise from forces of technology push or marketing pull or from both.

TECHNOLOGY PUSH VERSUS MARKET PULL

Over the years, the issue of technology push versus marketing pull has engendered much discussion and controversy (Chidamber & Kon, 1994; Ettlie, 1993; Kleinknecht & Verspagen, 1990). Typically, the issue focuses on the question: Which is better as a generic strategy? The answer should be "Both" since both are important, and both should be pursued as avenues for attaining competitive advantage. Yet, evolving answers seem to be related to the origins or memberships of respondents (Iya & Akhilesh, 1992). Individuals with strong backgrounds in R&D acknowledge the importance of customer inputs, but are highly oriented toward pushing innovation forward through new technology development. Those with backgrounds in marketing or sales (and perhaps all other areas except R&D) are excited by new technologies, but emphasize the pull from market-centered influences, and may insist that customer demand is the highest priority among various considerations.

While marketing pull and technology push represent two ends of a continuum, that is, both are operating to some extent in any organization, it is helpful to distinguish between the two perspectives using the innovation process as a model (Figure IV.1). In the marketing pull perspective, technology is developed or adapted for meeting the needs of the customer and the marketplace. Marketing plays the leadership role and R&D responds with appropriate technologies. It is generally important that R&D be sensitive and responsive to satisfying the needs of consumers. The continuing ability of R&D to satisfy more immediate customer needs gains leverage for R&D to do more of the longer range, exploratory projects it would like to do. Accordingly, a kind of a balancing of priorities is not uncommon, one in which marketing pull needs are served in order to pay the way for projects that are technology push in nature.

In technology push, new technologies are created through the technical core and, if necessary, consumer needs, awareness, and interest are developed along with the new products. R&D and/or operations may originate the

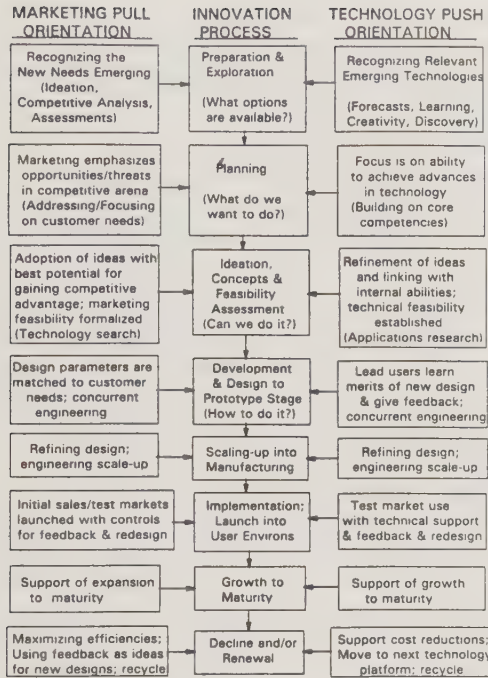


Figure IV.1. Marketing Pull and Technology Push Orientations Linked to Innovation Stages

process of innovation and may lead it as well initially, but generally with the concurrence of marketing.

In this text, our focus is on organizations or individuals that have in place, or can develop, significant technological capabilities. It is, therefore, a given that such organizations will invoke both technology push and market pull strategies. But, consistent with our contingency modeling approach, we assume that at certain points in time, one of the strategies will be especially emphasized. In particular, the emphasis may depend on which stage (initiating or implementing) of the product or technology life cycle is involved. At any point in time, an organization is engaged with a portfolio of technologies, so the two strategies may be operating tandemly. However, it is useful to first consider the two strategies separately, then to bring them together in the form of an integrated model.

Technology Push

In technology push, the organization (or the key individual) initiates and drives an innovation through the development of new technology. Most

commonly, the main focus is on internal development which permits the derivation of proprietary or unique positions. New technology becomes the mechanism for gaining distinctive competence or competitive advantage. Accordingly, organizations or individuals engaged in the technology push mode have the following capabilities:

- They are able to operate at the “cutting-edge” of technology in a particular area. This suggests that relevant individuals are available who have the necessary competence and discipline to operate at that level or can expeditiously gain the competence to do so. In other words, there must be a significant R&D capability within the organization or within the key individuals who are involved.
- Creative leaps in technology can be accomplished. Organizations can move from the mundane to the novel, from the ordinary to the extraordinary, and therefore have the creative potential and a favorable environment for achieving those leaps.
- Resources can be channeled for development of new technologies. Included among resources needed are people, time, materials, and money. In this context, it is important to recognize that “slack” is an important resource that must be available. Adequate cushions of time and other resources must be available to permit the sustaining of focus without having to dysfunctionally divert energies to performing other tasks. The cushions, in a sense, represent equities that have been accumulated from earlier investments.
- Product or technology champions are also available. These individuals help sustain interest and gain support from relevant constituencies throughout the course of the project. It is not uncommon for creative, technical individuals to also serve as their own product champions.
- There must also be a significant potential for usefulness of the development, once it is realized, either as an end in itself or as an important bridge to other attractive technologies. Frequently, the usefulness will be obvious as it was in such cases as the first telephone, the first airplane, etc. In other words, there is often the perception in technology push that, once realized, the new technology will be very attractive to end-users. So, in a sense, technology push begins with the assumption that market pull will be strong. The difference is that the assumption generally lies in the minds of the creators, at least in the initial stages of the project. Customers simply may not know they want something until it is beginning to become available.

In summary, technology push has the appealing characteristics associated with the *pioneering* of new developments. It tends to be a first-to-market

strategy that aims for sustainable positions and longer life cycles than might otherwise be obtained. Arguments for technology push are compelling. They center on both the opportunities for deriving lasting competitive advantage as well as on the pitfalls of having a rigid market-oriented focus that is short term in overall perspective (Arnold, 1992). Technological breakthroughs such as lasers, nylon, xerography, transistors, and many other landmark advances have arisen from technology-push orientations, when R&D had some degree of independence (Arnold, 1992; Souder, 1989). Porter (1983, p. 2) noted in discussing dimensions of competitive strategy that "the power of technology as a competitive variable lies in its ability to alter competition through changing industry structure." Successful radical inventions such as the transistor, the personal computer, and the cellular telephone certainly altered industry structure and revolutionized how things are done. Technological leaders are able to achieve significant competitive advantage that can be quite lasting (Lawless & Fisher, 1990). An inability to lead through developing new technologies tends to increased erosion of competitive position. Buggie (1993, p. 37) notes that "if your company is 'market-driven,' the market can drive you to destruction." Vulnerability to eroding competitive position may be expected to eventually increase if firms excessively down-size and reduce their ability to lead technologically (Blaxill & Hout, 1991). Erosion of U. S. technological leadership has been attributed to factors that include an overemphasis on short-term financial and marketing perspectives (National Science Board Committee on Industrial Support for R&D, 1991).

There are potential downsides to technology push, however. Developments may be impractical or may not lead to implementation because of lack of demand in the marketplace.

Market Pull

In an orientation toward market pull,¹ the driving force behind new developments originates from consumers or users of those developments (Aaby & Disenza, 1993; Cleland & Bursic, 1992; Foster et al., 1985). The potential user identifies a need for interesting products which possess new features, or represent an elimination of some deficiency in an existing product. A very familiar driver of market pull occurs in response to requests for lower priced items that possess equivalent or even improved product features compared to earlier product models. Serving the technological needs of customers, and operating within their constraints of costs and benefits, can be extremely challenging to R&D, requiring very high levels of creativity. Features of market pull include the following.

- The primary attribute of market-driven products and technologies is that they arise from *needs* emanating from the marketing

environment. This is in contrast to technology push situations where ideas come from scientific study and speculation. So, in market pull, the emphasis is on what needs to be done to serve the interests of the consumer, rather than what can be done without the necessity of any explicit customer need.

- Needs are identified through a variety of instruments, formal and informal. Reliance may be based on written responses to survey instruments or on informal conversational inputs from some key individuals or on a combination of both (Fishman, 1989). The act of dialoguing with potential users on issues relating to emerging ideas for new technology places those ideas in the public domain. Those ideas may begin to be diffused throughout the environment or industry. So, there is a tradeoff between the need for information and the need for secrecy. Reliance on the identification of customer needs may, therefore, invite higher levels of competition than might otherwise arise.
- Explicit market demand for the product, process, service, or technology is already evident to some degree. With marketing pull, it becomes unlikely that elegant new technological developments will just languish on the shelf because of the absence of consumer interest.
- The marketing function within organizations, along with sales, are dominant players and drive activities through initiation and coordination of the efforts of other functions. The top management infrastructure may drive marketing, particularly if the power structure of the organization is highly marketing oriented. Finance is also a key player because of the consistency of the needs pull orientation with attainment of short-term profitability.
- Time horizons for the needs pull orientation tend to be shorter because of more intense competition, the tendency to satisfy emergent demand more quickly, and the shorter life cycles that evolve from satiation and obsolescence.
- The ongoing technology policy in the needs pull orientation tends to focus on *incremental* advances rather than radical ones.

The market pull approach helps to ensure that the needs of customers, present and potential, are served. Since customers are buyers of, or investors in, an organization's goods and services, serving their interests is necessary in order to be relevant. The basis for the needs pull approach has a long and rich tradition, emanating through the marketing concept (Kotler, 1967) and continuing to the present time through the emphasis on the desirability of a customer orientation in achieving excellence (Peters & Waterman, 1982).

Figure IV.2 summarizes the advantages and disadvantages of the technology push and needs pull approaches. Each has important advantages

		Advantages	Disadvantages
Technology	Push	• Can build quasi-monopolies (high sustainability) • Can leverage to other technologies • First-to-market advantages are more likely • Can build new core capabilities, new infrastructures • "Big Bangs" may create whole new industries	• Requires longer lead times and a relatively high investment • Requires lead-users to establish need • Other competitors may still enter the market first • End-products of new technologies may not be wanted • Developments may not have marketing feasibility
	Marketing Pull	• Marketing pull facilitates adoption • Known demand exists in the market-place • Minimizes investment; maximizes <i>short-term</i> return • Helps in building alliances with customers • Technology may be more readily available	• May become a highly "reactive" mode • More competition is likely • Innovations may tend to be more mundane • Shorter life-cycles tend to become more likely • If technology is not reachable, credibility becomes threatened
Push-Pull		• Potentially, the best of all possible worlds • Project portfolios are quite possible	• Certain elements offset or are mutually exclusive • If require both, launch time may be delayed

Figure IV.2. Advantages and Disadvantages of Technology Push and Marketing Pull Postures

and, therefore, it is desirable to strive to optimize both approaches, if not simultaneously then tandemly, in pursuing innovations. A technology push option should be brought into focus when there is demonstrated capability for pioneering technologies, when the anticipated effect on performance is favorable, when the option is consistent with technology policy, and when the influence of customers and other stakeholders will ultimately accept it because of expected results. A marketing pull strategy is supported when cash flow requirements have to be met, when pioneering capabilities are limited, when high levels of success are achievable by serving customer interests, when customers are very powerful, and when technology policy favors it. A rather delicate balancing act may be necessary because certain opposing forces between the two postures may be triggered. The needs pull approach may become self-perpetuating and lead to a condition of mediocrity and loss of distinctive competence if the organization fails to pioneer truly new technologies. The technology push approach may become victim to a zero-based-budgeting or a profit-maximizing focus if ongoing cash-flow requirements are not fulfilled. Given these opposing forces, an appropriate balance is needed such that one approach helps to sustain the other. That balancing or integration of joint policies requires continuing effort since there are forces at work which tend to preserve the viability of one over the other.

INTEGRATION, STRUCTURE, CONFLICT, AND COOPERATION

The need for integration of marketing and R&D has been underscored in several excellent works (Souder & Moenaert, 1992; Moenaert et al., 1994; Pearson & Ball, 1993). Munro and Noori (1988) found that integrating push and pull perspectives was beneficial in the process of incorporating automated manufacturing systems. These and other findings provided support for the later emphasis on integrated cross-functional teams as means for promoting the quality and timeliness of product development efforts (Clark & Wheelwright, 1993). Rothwell (1992, p. 222) devised a "coupling model of innovation" which included a "new need" and a "new technology" as components. A triangular model, involving elements of marketing, R&D, and manufacturing, has been considered very important in managing the production/R&D interface (Ginn, 1983, p. 157). In Figure IV.3, marketing, R&D, and manufacturing form three sides of a triangle that is at the heart of the innovation process. Ideally, the three subsystem elements articulate in generating and implementing new ideas into innovative products and services for the organization. Yet, even with such idealized perspectives, residues from earlier models continue to exist in real world experiences. Functionality and division of labor remain as

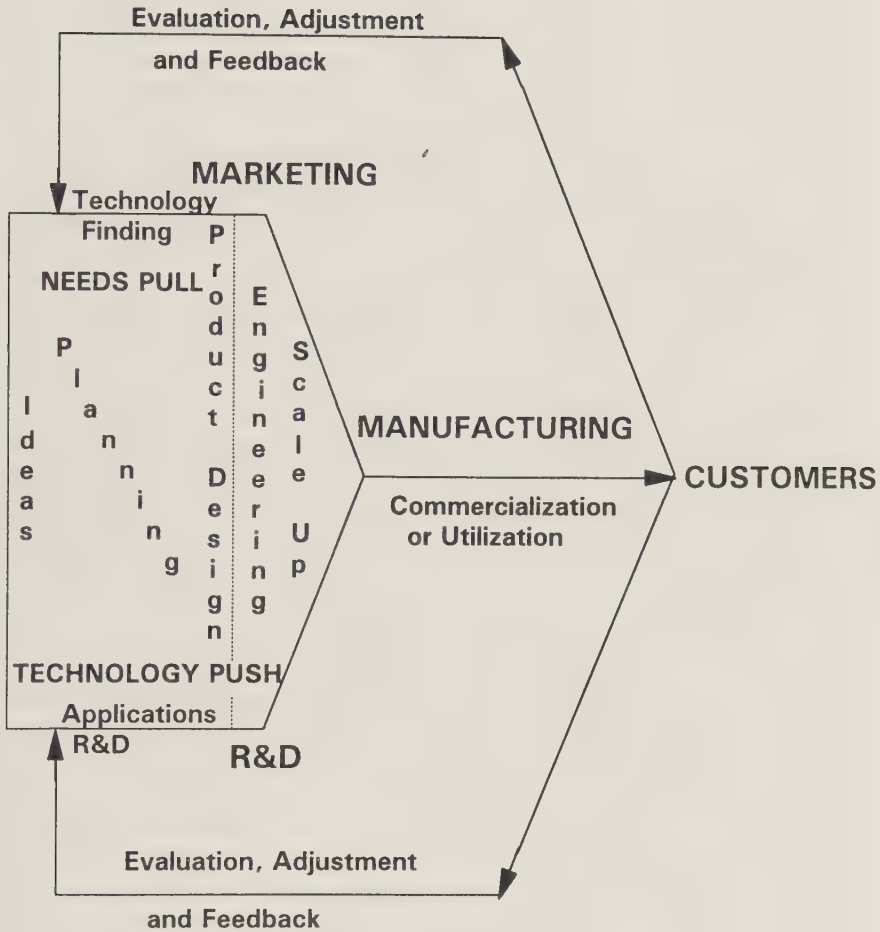


Figure IV.3. An Integrated Innovation Model with Technology Push and Marketing Pull

important concepts in innovation management (Allen, 1986; Chakrabarti & Hauschildt, 1989).

The distinction or demarcation between market pull and technology push is not always precise, as our earlier discussion assumed for the purposes of definition. For example, in technology push, needs may not be expressly indicated in the marketplace by consumers, but they may be strongly implied and logically obvious to discriminating innovators. Technology push also creates new needs. So, the trend from market pull to technology push, and vice versa, may be more like a continuum.

Cleland and Bursic (1992, p. 119) suggest that "the difference between research developed from a technology push and that from market pull has become less important." They argue that "all R&D serves profitability." According to Brown (1992, p. 48), "...the debate over the extent to which radical innovation is caused by 'technology push' or by 'market pull' will continue for years." In any event, there is no doubt that the development of new technology, leading to new products, does provide opportunities for growth and renewal and the sustainability of competitive advantage.

Project acceleration, including the compression of product life cycles, is another issue of importance in understanding the dynamics of integration between marketing and R&D. There has been a push to accelerate new product development. Shortening of the time-line for development, for example, through concurrent engineering and cross-functional teams, has been widely touted as a means for increasing revenues and competitiveness in technological innovation (Rothwell, 1992; Clark & Wheelwright, 1993). The genesis for this is not new. Going back to the 1950s and 1960s and continuing to the present time, it has been recognized that a "window of opportunity" exists for any given new development (Burger & Aderohunmu, 1992). Such windows exist because technologies advance in broad streams and organizations tend to become aware of emerging opportunities at similar points in time. Accordingly, a competition frequently arises with respect to which firm can be first into the market in order to obtain first-mover advantages. Being able to build a market position before competitors enter is highly valued and has given impetus to the need for the various functions to integrate their activities as expeditiously as possible. This impetus is experienced as pressure or imperatives for action at all organizational levels, including at the level of the creative technologist.

The desirability for accelerating new product development and introduction into the marketplace is not without limitations. Acceleration leads to higher levels of stress and might increase the number of errors encountered, yielding higher risks, as from premature introduction (Millson, Raj, & Wilemon, 1992). Acceleration may also lead to the institutionalization of a short-term mind-set, when operating entirely to satisfy *market pull* forces. In such cases, radically new, interesting developments that require longer lead times may be superseded by shorter-term, incremental developments. A process of creeping incrementalism may then result.

Shorter, faster life cycles can also lead to other serious problems that constitute what von Braun (1991, p. 43) described as "the acceleration trap." In such cases, lowered sales and greater risks are ultimately experienced by technology push companies if they introduce and phase

out new products too rapidly. On the other hand, longer life cycles reflecting substantial revenues and profits over extended time periods are enormously important in enhancing the viability of a firm. It would seem that considerable attention should be given to finding ways to lengthen the term of the life cycle instead of simply accelerating its demise. Longer life cycles result from high-performing products that are unique in qualities and are proprietary in nature. To a great extent, uniqueness is accomplished by creating and or applying some new technologies in designing or producing the product. The situation is complex however. Part of the equation that sustains new product viability is the ability to introduce the product early and be able to build brand identity, brand loyalty, and other entry barriers to competition before competitors are able to enter the arena.

The forces that emerge from interactions between R&D and marketing derive from a host of product development activities.² These interactions occur throughout the various stages of the product life cycle. Marketing and R&D have similar aims, that is, the building of competitive advantage through the development and introduction of new products. But, they approach implementation differently because of their different functional perspectives, their different elements of expertise, their different bases for information. By definition, marketing is strongly customer oriented; R&D is strongly technology oriented. Accordingly, the extent to which individuals in each group develop and exercise familiarity with the other's modus operandi contributes to better interfunctional relations. The interrelations between R&D and marketing are also influenced by the nature of their sociopolitical roles in the organization they are operating in, as well as the nature of the organizational culture.

Certain organizational options are available for attaining effective performance in developing and launching new products into the marketplace. Options include a marketing orientation, a technology orientation, and a peer orientation. In both the pure marketing and technology-oriented approaches, one functional department holds preeminence in influence or power over others. In such cases, one would expect relatively low levels of diversity in approaches and low levels of conflict since one department is basically in charge. The third approach, the peer-orientation approach, is perhaps the most powerful of all. In peer orientation, the functions contribute as coequals in serving the greater interests of the organization in meeting consumer needs (Figure IV.4). The departments operate under a general manager or chief executive officer, with each striving to maximize its contributions so that the total performance of the organization is enhanced. Along with the basic structure, matrices, ad hoc clusters and integrated cross-functional teams are commonly employed to improve performance. Conflicts commonly

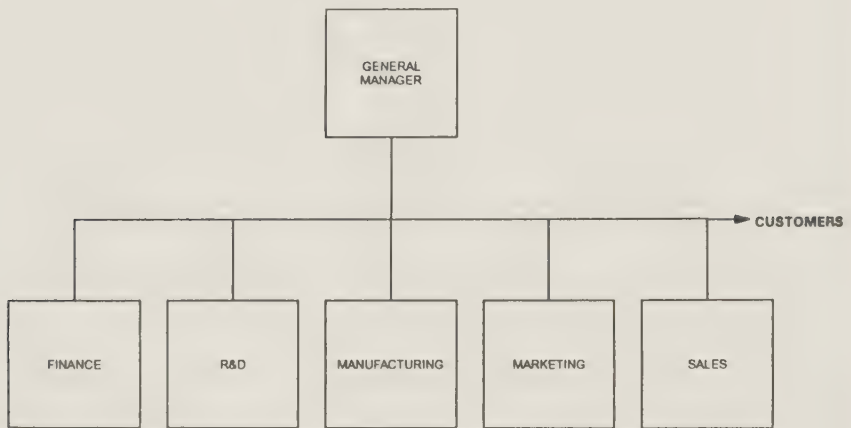


Figure IV.4. The Peer Orientation Organizational Option

arise in the peer-orientation structure.³ Some of the elements that can contribute to conflict follow (Ginn, 1981; Schmidt & Kochan, 1972).

- *Differing Priorities and Agendas:* Different functional groups are frequently measured by different criteria in evaluation and in their day-to-day efforts. As a result, each group tends to espouse those goals which are compatible with the departmental goals. When departmental goals become incompatible with those of a different group, perhaps those of a cross-cultural project team, serious conflict can occur (cf. Schmidt & Kochan, 1972). Conflicts can arise when the goals of one project team become incompatible with the goals of another project team or with management as a whole.
- *Imperatives for Action:*⁴ Along with incompatible goals, the existence of organizational imperatives that impel individuals to action tends to exacerbate the conflict that occurs.
- *Exercises of Power:* Power and conflict are intimately linked as organizational variables and tend to be codeterminants of one another.
- *Non-Peer Relations:* Relationships that start out as favoring equality of power and authority may become imbalanced because one group can more effectively cope with the uncertainties that arise. Such imbalances can be beneficial at first, but may lead to intergroup problems at some later time or to a condition of suboptimization.

- *Territoriality*: As occurs in the animal world, territorial behavior, behavior that tries to exclude others from entering a domain, can occur when conflict becomes especially severe. When it occurs, individuals may feel like *intruders* as they try to enter another environment or subenvironment.
- *Limited Resources*: In general, organizations are operating with limited resources of time, people and money, and increasingly so when downsizing programs are instituted. As a result, competitions frequently arise for limited resources. This also exacerbates conflict.
- *Interdependence*: Since the individuals and groups participating in the innovation process are highly dependent upon one another in order to achieve success, contacts cannot be avoided. Indeed, avoidance, which is a form of conflict resolution, can only undermine efforts toward innovation in the long run.
- *Uncertainty of Requirements*: In the domain of innovation where new things are being tried, uncertainty is inevitable. Uncertainty tends to add more pressure to various situations. When requirements shift, as from changes in desired product features, or from new manufacturing cost structures, even more pressures and frustrations tend to arise.
- *Pride of Authorship*: All operating factions enjoy rewards and recognition for their accomplishments. That can be wholesome and may trigger healthy motivation. But, when the players become excessively competitive, even obstructionist, such pride of authorship can be harmful.

Each department tends to have a strong internal identity. Substantially different priorities and agenda items may be encountered at any given time. Yet marketing and R&D must operate conjointly in achieving the timely introduction of new products and services. There is an essential interdependency which exists between the two departments.

Along with the interdependency, there are subcultural differences that exist between R&D and marketing personnel. There are differences in training, in level of focus to the consumer, in willingness to risk, and in the styles that are utilized in arriving at decisions. All of the above differences result in different responses to the operating environment as manifested by the setting and accomplishing of goals. Such differences can lead to power struggles, to distorted communications, and to conflicts that are dysfunctional in nature (Ginn & Rubenstein, 1986). The nature of interactions, overall, depend to a great extent on the operating culture of the organization and its leadership. What the

top leader does as situations develop, or does not do, has an ongoing impact on the relationships that become institutionalized.

The origins of dysfunctional conflict were postulated by Schmidt and Kochan (1972) to be related to incompatible goals as well as to other factors. A key factor leading to dysfunctional conflict is the existence of goals which are perceived to be incompatible with the internalized objectives of each department. For example, marketing might have the goal of introducing a particular new product at the earliest possible time in order to gain early returns. R&D, on the other hand, might want to take more time to test and confirm product stability upon aging. Marketing might want to be flexible and be able to add new features to an evolving product in order to improve its competitiveness in relation to a newly introduced competitive product, arguing that ground rules are shifting. R&D might be reluctant to add new features because their targeted time frame goals would be missed. So wanting to be cooperative and yet understanding that cooperation interferes with attainment of other goals represents a dilemma which is not uncommon in product development. These positions reflect the presence of incompatible goals, that is, situations where the achievement of one set of goals by one subsystem virtually precludes the achievement of goals by the other subsystem.

Differences in goal orientation can commonly surround or cause problems between functional subsystems in innovating organizations (Ginn, 1983). Goal differences have been associated with such problems as: products being introduced into production prior to readiness, interference with manufacturing productivity levels, and controversies on scheduling priorities and on the nature of the production equipment that is to be utilized. Different notions can exist about what activities are to be considered urgent. Such differences are related to differing value systems and, in extreme cases, are characterized as examples of "departmental myopia."

In addition to differing goal orientations, there is normally a high incidence of limited resources coupled with the high degree of interdependence between the two departments. Given these ingredients and the opportunity to interfere with the other's activities, dysfunctional conflicts are likely to occur. It is also observed that the conflict is made more or less severe by the uncertainty that exists in the environment and by the imperatives placed on the system to act and when to act.

Although there are many situations where conflict can arise, there are also forces operating that would tend to promote cooperation between the two areas (Ginn, 1981). In other words, there is a commonality of interests, which would include the items listed in Table IV.1. Both marketing and R&D are strongly success oriented. Yet neither

Table IV.1. Some Areas of Commonality

Marketing	R&D
(1) Commercial Success	(1) Technical Success
(2) Brand Identity	(2) Aesthetic Qualities
(3) Points of Difference	(3) Technical Uniqueness
(4) Proprietary Position	(4) Patentability
(5) Product Promotion	(5) Desire to Publish

department can be genuinely successful without the other also being successful. Both are interested in achieving the highest quality products possible and building strong brand identities through the introduction of aesthetic qualities. Both want products to be recognizably differentiated—even unique in functionality. Both seek proprietary positions for their products by obtaining patents or by maintaining valued trade secrets. Both strive to promote their products and accomplishments either through advertising promotions or through journal publications. So considering all such activities, there are many commonalities of interests between R&D and Marketing. Those commonalities represent avenues for cooperation that can be built upon in achieving an integrated team effort (Figure IV.5). The general manager or the chief executive officer has a key influence on the nature of the overall climate of the organization. A “tone” is created which defines how various departments will interact. The general manager may in a sense encourage conflict by what he or she does or does not do. The general manager may be reactive, merely serving as an arbiter, or may be proactive in generating an atmosphere which encourages cooperation. Dysfunctional conflict can be reduced, according to the model of Figure 5, by gaining agreement on superordinate goals (Hunger & Stern, 1976) which diminish the influence of internalized, incompatible goals. Ideally, the climate should include participative decision making or problem solving on the basis of real participation at peer levels. Cooperation would also be enhanced by making certain that requirements are clarified and commitments made as a result of participative discussions. A sharing of resources would then be more likely to occur and that should lead to responses that are more effective and of longer duration. While uncertainty in the environment and imperatives for action will always exist, those difficulties can be addressed on a more unified basis.

As we move into the twenty-first century, we can expect that even greater demands and challenges will be encountered. The pace of technological change and levels of global competitiveness are expected

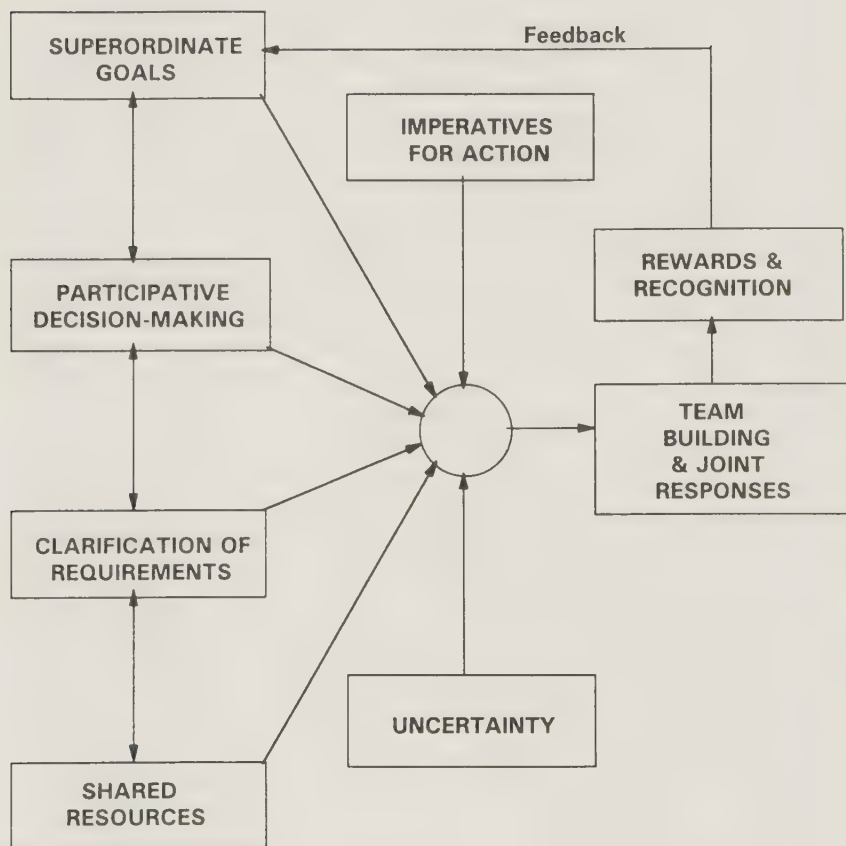


Figure IV.5. A Model for Cooperation and Team Building

to increase. It is assumed that organizations will have to be more innovative than in the past in order to be successful. The need for greater levels of cooperative action between R&D, marketing, and other functional subsystems will be even more important than in the past.

Insights from a Marketing Executive

Interview with George N. Alexy, Vice President of Marketing, Cirrus Logic, Inc., Fremont, California⁵

Mr. Alexy: First, a little on my background. I did my undergraduate work in engineering at Drexel University, then went on to obtain an M.S. degree in electrical engineering. So I am technically trained. My industrial experience began with Univac, then with Intel in applications engineering, which brought me to California. At Intel, I moved into the marketing area and served as marketing manager. I have continued in the marketing area since joining Cirrus Logic, and now head up that activity.

I believe that technical creativity is enhanced by two elements in particular. First, an environment is needed where there is latitude given to express creative ability. Secondly, the individuals involved must have the desire to excel and to be successful. They need to have a wish to be the best, both as individuals and as contributors to organizational success. These elements are particularly important for smaller companies. Creative individuals must be "there" in supporting the company's success. They must have the drive to excel. They must respond to given directions reflecting company needs. They have to deliver results within established time frames.

Interviewer: So, in a sense, there is a special interaction between the contributor and the company, an interaction which is a key element of technical creativity.

Mr. Alexy: Exactly. I can give you a significant example. I can recall a particular case where a key customer of an organization asked for new input/output characteristics for an integrated circuit. The request was made only one month before the end of the project. The initial schedule of four months had been difficult and tight even without the changes in protocols. The requested changes required massive changes in architecture. We could not ignore the request because there was a major competitor also working on the problem. And there was a major customer demanding the new technology downstream. So there was a lot of pressure on this particular project. Surprisingly, an engineer, using his creative powers,

solved the problem over a weekend. His new design was entirely effective. As a result, the organization met its commitment and derived substantial revenues.

So, it is the *opportunity* to create *and* the *challenge* to create that really drives creativity in the industrial context. The challenge can stem from various sources: from moral imperatives, from a need for technical fulfillment, from a desire to thwart a competitive threat, and so on. And there is a chain effect that results from creativity. If one group is successful, then another group perceives that it too can be successful. In other words, it is perceived that we, as an organization, can invent and come up with new ideas to serve our markets.

Interviewer: So, a tradition emerges.

Mr. Alexy: Yes, and what motivates engineers most is the feeling that, if they excel, the company will excel. The two coming together provides fulfillment. So, the organization gives a challenge which represents an opportunity for the engineer. To do that, there has to be direction coming from the company. But, the company should not give too much direction. It should give the basic problem, the basic need, and then the opportunity to be creative.

Interviewer: If these elements motivate engineers, what demotivates them?

Mr. Alexy: Engineers are demotivated when they work on a problem and solve it, then find that the solution is not utilized. They are demotivated if we tell them to do the wrong things. We have to be very careful in this regard.

In some respects, we are managing in ways that build self-esteem. Part of an individual's self-esteem derives from tangible rewards; another part derives from intangible rewards. They're all interconnected. One of the old "rules of thumb" relates to how successful do the recipients feel they are as a result of receiving a given reward. I find that there are three types of individuals, in this regard:

1. the "power types," who derive satisfaction from being given more influence, more authority, as a result of their accomplishments,
2. the "acceptance types," who enjoy receiving awards, salary increases, or bonuses, and
3. the "leader types," who derive satisfaction from the opportunity to train or teach others how to become more creative.

So, individuals have different “spins.” Managers have to be able to realize what these spins are, and be able to give appropriate motivation depending on these spins. So, appropriate rewards may be psychological, emotional, or tangible.

Coming back to what demotivates, two things limit individuals: first, the issuing of wrong directions that erode confidence in management; and second, putting individuals into “too small of a box.” It is important for managers to stay out of “their sandboxes.” Technical individuals are especially sensitive in this regard because they are used to solving problems by their own methods. That gives them satisfaction and enjoyment. So, managers need to guide, to educate, to teach, but not to tell them what and how to do it. That is the challenge for management. Management has to ask salient questions. Sometimes the appropriate management style depends on what’s at stake. It’s “situational leadership.” For example, sometimes if appropriate, you are dictatorial; other times you let people fail and learn from their failures.

Interviewer: Is it really OK to fail in industry, in a competitive environment?

Mr. Alexy: Sometimes it is important to let a schedule slip to make sure that a big failure is avoided. In my own particular perspective, I understand that there is a trade-off between technical elegance and time-to-market. I like to picture this relationship as a 2x2 matrix (Figure IV.6). According to this matrix, questions arise when you’re either late with a good design or early with a poor design. The question for management is which is preferable when these are the only choices that you have. Sometimes, if you are early with a poor execution it will be better than executing well and being late. But, it depends on how “poor is poor.” Sometimes, there is a very fine line between the time line and elegance of solution. The situation is complicated since there is normally not a linear relation between time allowed and elegance of design. Inevitably, such situations require a “judgment call” by the people involved. And sometimes, management has to step in to make the call.

		<u>Technical Design Elegance</u>	
		Good	Poor
Time- to- Market	Late	?	Lose Situation
	Early	Win Situation	?

Figure IV.6. Matrix of Time to Market versus Elegance of Technical Design

The problem of time line also relates to the industry life cycle and the time required for getting a new development introduced into the system. For a manufacturing life cycle, the time needed may be 2-3 years in duration. But, the marketing life cycle might only permit a window of one year. We are working in a highly competitive industry. So getting a new product design into a system, with the proper timing, is a real challenge for our company.

Our company, Cirrus Logic, began in 1985. Although it started with the development of software tools, integrated circuits are now our main products, not software. We see a great opportunity to grow through integrated circuits. The opportunity is in the range of \$0.5-1 billion. We feel that our distinctive

competence is not only our engineering skills and technology, but how we focus our efforts. We identify “transitions” early and then provide the technology to bridge those transitions. In our dynamic industry, planning is very challenging. Our “long-term” planning horizon is only three years.

We anticipate the needs of our customers in moving from one technology to another. For example, we have just completed the acquisition of an analogue systems company. This acquisition permits us to go from digital to analogue systems, a transition of importance for graphics. We are also growing internationally and through acquisitions. Our acquisitions are driven by market and technology needs and by how well candidates fit with the technological and market goals of our company.

MINICASES

Minicase IV.1. CEO Dilemma on Divisional Manager's Mind-set

Scenario. You are the CEO of a multidivisional corporation which is segmented according to product-type and industry served. Each division is headed by a general manager. One manager seems successful enough in terms of sales and profit growth, but seems to be a maverick wanting to do things his own way. He seems to always be flirting with possible disasters. Sales are strong on various product areas, but they seem to be pulsed, that is, always coming in just before the end of each quarter. He manages much like a cavalry officer, sort of making charges to save the day. These tactics put a lot of strain on his functional managers, that is, on managers of sales and marketing, manufacturing, finance, and R&D. Yet, the results are there. You are uncomfortable with the situation because you don't like the style, and you feel that you cannot control the situation. You finally get the idea that the best way to “train” this manager is to introduce a “competitive element,” an individual who would be doing similar things at a similar level in order to create a level of tension so he will fall into line. You authorize the creation of an associate manager post and recommend staffing it with a conservative individual that you have approved. Oddly enough, after introducing the new individual, the general manager's performance now seems to be slipping. You wonder if he should be fired. WDYD?

Discussion. The question in this case is whether a top manager can or should tolerate operating styles of key subordinates when those styles are somewhat effective but deviate from preferred approaches. Impacts on performance as well as on the behaviors of other individuals and groups must be assessed. Should mavericks in innovating organizations be tolerated, and if so, to what extent? If deviant styles are to be constrained, how should that be done without squelching motivation or limiting performance? Certainly, there should be sensitivity and awareness of possible consequences before actions are taken.

Minicase IV.2. Chicken Wings

Scenario. You are the vice president of R&D and are flying to the coast with your boss, the CEO. She is reviewing three resumes with you—three candidates for the top marketing job in the company. You have voiced enthusiasm for one of the candidates who is a seasoned professional—and one you know you can work with effectively. Another of the candidates is relatively inexperienced and seems highly abrasive to you. All the other managers who interviewed him found him to be either irritating or abrasive—to varying degrees. You wonder about the individual's judgment on upcoming key decisions and you know he will create much conflict. But the CEO wants to “shake” the organization and likes his aggressiveness. You feel sure that the CEO will hire this individual no matter what you say—yet, she asks for your final selection, apparently wanting your concurrence. Assume that the CEO is new and has been given a charter to move the company forward into new markets. WDYD?

Discussion. The new CEO obviously has a specific agenda or mission aimed at changing the organization and wants to facilitate that by introducing a new aggressive individual, one who is not liked by the R&D executive. Should those feelings be expressed by the R&D vice president, or should one simply “go along” knowing what the new CEO is after? Such doubts can be expressed, but in transmitting those feelings, it is important to consider possible benefits to the organization as a whole as well as to impacts on specific players.

Minicase IV.3. R&D and Marketing Footdragging?

Scenario. You are the operations vice president of a firm and have completed installation of an FMS (flexible manufacturing system) plant-wide. Your product line consists of packaging containers for the consumer products industry. With programming capabilities in place, you can now produce many varieties of product on the same basic equipment. Prior to

this point, you (your department) was the “bottle-neck” in commercializing new products—and R&D and marketing were complaining. Now there seems to be a lack of new designs and new marketing programs, at least considering the quantity needed to effectively utilize your equipment. Also, each minute difference of opinion, misunderstanding, or miscommunication causes intolerable delays. You and your CEO are distressed. WDYD?

Discussion. New technologies developed within organizations can shift the balance of power from one constituency to another. Contributions required from functional entities may also change substantially. In this case, manufacturing has developed greater capability for shifting from one product to another, while design and marketing capabilities may not have kept in step. Organizational improvements, such as mechanisms for improved communications and increased integration should parallel the development and adoption of new technologies. That is not always the case. Organizational development generally lags behind.

Minicase IV.4. “Relax!—You’re Working Too Hard”

Scenario. You are a marketing products specialist trying to become a product manager, and eventually a director of marketing. You are working very hard because two other people in your group are also being considered for the promotion. You are on top of each new product program within your responsibilities and you are vigorously coordinating your programs with R&D, sales, manufacturing, and finance. You have irritated some people by insisting that you want to get things done and done on time. Yet you have been trying to have good relations. You are also getting your MBA in an evening program. One day, your boss, who would like to retain the status quo, says to you: “Relax, you’re working too hard.” WDYD?

Discussion. At issue here are the interpersonal skills of the marketing specialist in managing cross-functional teams as well as the boss’s possible political agenda in connection with the envisioned promotability of the specialist. Most practitioners suggest that the specialist should not necessarily slow down, but should become more sensitive to interpersonal relations, and should dialogue with the boss to determine what was behind the statement made. Benefits can be derived from exploratory confrontations provided these are done skillfully.

NOTES

1. In this work, there is interchangeable use of the terms: market pull, marketing pull, needs pull, demand pull, and marketing driven.

2. An extensive literature is available on the issue of the R&D and marketing interface. In particular, the researches and writings of Professor W. Souder and colleagues are especially rich sources of information for this topic. For examples, see Souder & Moenaert (1992) and Moenaert et al. (1994).

3. Conflicts may be good (having positive results) or bad (yielding significant negative consequences) (Thomas, 1976). Good conflicts are situations where disputes lead to better solutions or to improved relations, without any serious costs. On the other hand, bad or dysfunctional conflict results when significant costs are irreversible.

4. Imperatives for action are events or conditions encountered in the operating environment which compel individuals or groups to act in some way. Examples of such events would include directives from top management, a major competitive thrust, a serious societal or legal or economic dislocation, etc. In the minds of the players, they represent problems that must be addressed or opportunities that must be pursued. They can be ignored only with great difficulty (Ginn & Rubenstein, 1986).

5. The interview with Alexy was conducted on November 11, 1991.

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CASE 4. PEAPOD DELIVERY SYSTEMS INC.: AN ON-LINE COMPUTER SERVICE INNOVATION

It was the weekend—late Saturday morning. Thomas L. Parkinson, vice president of Peapod, and several members of the company were busily working in their offices. Dress was very casual. People moved in quick-time. Conversations were animated. Some individuals were doing software development and problem solving at PC stations. The pace was brisk. T. Parkinson indicated that all of this was quite normal at Peapod. The work continues into the evenings. Putting in long hours derives from the nature of the company's service, but also from the requirements of starting a new business.

According to Andrew B. Parkinson, president of Peapod,¹

Our *mission* is to become the leading on-line computer grocery shopping and delivery service in the United States. That activity will generate revenues for our company. If we are the leading player, then other opportunities will evolve. As an example, we can become a leader of on-line grocery advertising and, later on, a leader of marketing research, once we have reached the appropriate size.

BUSINESS PLAN OF 1991 FOR PEAPOD DELIVERY SYSTEMS: EXECUTIVE SUMMARY

Peapod Delivery Systems, Inc. ("Peapod" or the "Company") has developed the software systems and a service organization which enables consumers to shop for groceries from their local grocery chain over a personal computer and standard phone line from home or work. The consumer can review prices, scan for specials, and even sort by price, while placing an order in just minutes for delivery a few hours later.³

By drawing a substantial number of consumers to their computers *regularly*, Peapod has created an extremely effective advertising medium and an innovative source of consumer market research. Peapod's goal is to become the leading source of on-line consumer services by leveraging its expertise, software systems, and service organization in communities throughout the United States.

History

Incorporated in July 1989 and headquartered in the Northwestern University Technology Innovation Center at 1840 Oak Avenue, in Evanston, Illinois, Peapod was founded on the belief that a tremendous opportunity exists within the \$380 billion retail grocery industry, given that "grocery shopping is the least favored of all household chores" (N.Y.

Times, 9/30/90, p. 40).⁴ Recognizing the widespread availability and rapidly declining prices of personal computers and modems, the Company saw an opportunity to significantly lighten the grocery shopping burden by providing consumers with the ability to shop on their computers from home or work. By attracting consumers to their computers on a regular basis and by maintaining a complete demographical database of all transactions, Peapod also saw an opportunity to create a new advertising medium and unique source of consumer market research.

In conjunction with raising more than \$400,000 from private investors and a grant from the Northwestern University Technology Commercialization Center, Peapod reached an exclusive agreement with Jewel/Osco (the largest grocery chain in Chicago and a subsidiary of American Stores) to provide an interactive computer grocery shopping and delivery service in the Chicago market. After one and one-half years of software and systems development, Peapod introduced its computer grocery shopping and delivery service into a full-scale test market consisting of Evanston, Wilmette, and Kenilworth, Illinois. The market test began July 5, 1990. Given the success of the market test and having refined its software and systems to fully reflect consumers' needs and expectations, the Company is now preparing for expansion, both throughout Chicago and into other cities.

Products/Services

Peapod has specifically designed its on-line grocery shopping service so that the value to the consumer is outstanding. To become a member of Peapod, the consumer pays \$49.95⁵ for a start-up software package which gives them six months use of Peapod. Following the six month trial period, consumers pay an annual fee of \$34.95. There were no on-line charges other than for local phone calls. Once an individual becomes a member, Peapod will shop and deliver each grocery order for \$3.95 plus four percent of the total grocery sale.⁵

In addition to the above fees, Peapod's revenue comes from: 1) collecting fees from the participating grocery retailer; 2) selling market research information and services to manufacturers and retailers through its Integrated Consumer Marketing (ICM) Division; 3) selling advertising on Peapod to local and national advertisers who wish to reach Peapod's attractive audience; and 4) selling additional on-line services such as E-mail and electronic forums to consumers and small businesses.

Peapod has designed its software to be technically superior to all current on-line services. Built upon an advanced distributed processing architecture, Peapod is extremely fast and easy to use. The service allows consumers to view prices on more than 15,000 Jewel/Osco items. Consumers review

specials, and even sort by unit price to determine the best value. Peapod has been connected to the Jewel/Osco mainframe so that it receives updated prices and specials daily. The Company has also developed proprietary shopping and delivery routing software, as well as advanced back-end accounting systems which track all consumer purchases, account balances, and screen accesses.

As important as its expert systems are, Peapod employs and trains both the shopping and delivery personnel in order to maintain complete quality control over the entire shopping process (i.e., from ordering, to shopping, to delivery). All Peapod shoppers and drivers wear uniforms and are trained extensively to ensure superior service and the absolute fulfillment of customers' expectations.

Finally, Peapod's systems and training procedures have been designed to enable the Company to expand rapidly into new markets. The Peapod software has been designed to be modular, extremely flexible, and portable across hardware platforms, so that it can maintain a leading edge and make use of emerging technologies such as fiber optics and Integrated Services Digital Network (ISDN). The Company has also carefully documented training procedures and incentive plans for each type of employee to ensure consistently superior performance in each market that it enters.

Highlights To Date

In less than six months after opening its doors to the public, Peapod has enrolled more than one percent of households in its test market, giving it the greatest penetration rate per market of any existing on-line computer service. In addition, the Company successfully sold advertising to local retailers and has obtained market research contracts with two major consumer product companies. Most importantly, Peapod has proven its ability to attract consumers to their computers on a regular basis and has far exceeded expectations in terms of the consistency with which consumers log on and place orders. More than half of Peapod's members place an order between two and three times per month with an average order size above \$100. Peapod was recently described in the *Chicago Tribune* (10-29-90) as the "state-of-the-art home (computer) grocery shopping service ... which does it all."

In addition to its market success, Peapod has achieved other notable milestones. It was recently nominated for a *Computerworld* Smithsonian Award, an award which seeks to honor companies which have achieved outstanding progress for society through the visionary use of information technology. Its software has also been praised for its clear benefits to the disabled, as well as its ability to be used easily by the blind. Blind customers have thanked Peapod for making it possible to shop the grocery aisles by price and specials for the first time in their lives.

As for key alliances, Peapod teamed up with U.S. Robotics, a major modem manufacturer, in October 1991 and currently receives free technical assistance in addition to extremely favorable purchase terms on modems. Peapod was described as an example of one of U.S. Robotics' key end-users in their recent initial public offering circular. Finally, Peapod was exhibited (in 1991) in Arthur Anderson's Smart Store 2000, a leading consulting service for consumer product manufacturers and retailers, as an example of a leading trend in the grocery industry.

Management

The Peapod management team has consisted of five extremely hard-working and dedicated individuals who have excelled in previous work experiences (Exhibit IV.1).²

The backgrounds of the principals are as follows:

Andrew B. Parkinson

As a cofounder and president of the Company, Parkinson has overall responsibility for managing and directing the Company. In addition, he is responsible for financial operations and capital considerations. Andrew Parkinson has more than ten years of marketing and management experience and was promoted to manager of strategy for Kraft Inc.'s refrigerated products division, after spending seven years in brand management at Procter & Gamble and Kraft. As a brand manager, he was responsible for Kraft's largest product line which had sales totalling more than \$500 million and an advertising promotion budget of more than \$100 million. He successfully reversed declines on two separate brands and has introduced many new and successful products into the marketplace. A. Parkinson graduated from Wesleyan University in Connecticut with a B.A. in economics. He was also a member of the U.S. Olympic Boardsailing Team for two consecutive years and was selected as a coach to the 1989 U.S. Olympic Festival.

Thomas L. Parkinson

As cofounder and vice president of sales and customer service, Thomas Parkinson has overall responsibility for directing Peapod's sales and consumer service teams. In addition, he directs the design of the Company's consumer software and support systems. Thomas Parkinson has more than nine years of experience in sales, computers, product design, and small business fields. In 1984 he cofounded a small software company, Resource Control Systems (RCS) of New York, which specialized in UNIX⁶ based business systems. RCS reached annual sales of \$500,000. As vice president

Exhibit IV.1. Management Profile²

<i>Name</i>	<i>Age (1991)</i>	<i>Position</i>
Andrew B. Parkinson (Director)	33	President, Financial Operations, General Management
Thomas L. Parkinson (Director)	31	Vice President, Sales, Customer Service, Software Development
John A. Furton	27	Grocery Operations Manager, Training Policies
John A. Graham	41	Vice President, Integrated Consumer Marketing Division (ICM), Market Research, Sta- tistical Modeling
Jonathon J. Prettyman	29	Technical Manager, Systems, and Software Development

of marketing and sales he was responsible for eight employees and overall management of the company. He was also a designer of Placement Power Software, a package for executive recruiters and employment agencies. The software is currently being used by clients such as AT&T and Citicorp. Prior to working at RCS, Tom Parkinson was a sales representative for Procter & Gamble, where he was quickly promoted to district field manager. During college, he successfully started and ran his own small business, Parkinson Products, based on products he conceived and designed himself. Parkinson holds a masters in industrial design from Pratt Institute in New York, and a B.A. in design from Wesleyan University in Connecticut. He has received several art and design awards.

Employees and Advisers

In addition to the managers mentioned above, as of 1991 Peapod had hired more than 30 full and part-time employees. These employees include store managers, administrative and database management personnel, shoppers, and drivers. Peapod recognizes the need for a strong management and support team and, as such, carefully selects and cross-trains its employees in order to provide the extremely high level of customer service that has become the cornerstone of Peapod's competitive strategy. In order to attract and keep excellent employees, Peapod has established an innovative compensation structure which rewards shoppers and drivers for fast, courteous, and error-free performance. Peapod is also in the process of further refining its employee compensation system to enable all employees, particularly long-term employees, to share in the success of Peapod. In addition to the current management, Peapod has started to assemble an

advisory board comprised of highly qualified individuals with expertise in the on-line communications, market research, advertising, and database marketing fields. As of 1991, the Company was working or consulting with the following individuals and organizations:

Attorney and General Counsel: McBride, Baker & Coles, Chicago, Illinois,

Accountant: Peat Marwick Main & Co., Chicago, Illinois,

Communications Adviser: Casey G. Cowell, CEO and President of U.S. Robotics, Inc.,

Distribution Channels Adviser: Ann Coughlan, Professor, Northwestern University,

New Product Development Adviser: Dipak Jain, Professor, Northwestern University,

Market Research Adviser: Naufel Vilcassim, Professor, Northwestern University.

General Competitive Position

Peapod's general competitive strategy is to: 1) achieve superior knowledge of the needs of its customers within the market segments in which the Company competes; 2) provide superior, easy-to-use, and leading edge information products which meet the needs of these customers; and 3) match these products with service levels which consistently exceed customer expectations and foster long-term relationships with these customers.

Leveraging its superior customer service and technically advanced software Peapod will successfully compete and meet a significant need within four niche markets: 1) grocery shopping and delivery; 2) consumer market research; 3) on-line advertising; and 4) additional on-line services. Peapod will place more focus on grocery delivery and market research in the near term, followed by increased focus on on-line advertising and additional on-line services in the longer term. Each of these markets is reviewed thoroughly under the Products/Services and Market Analysis section of the Company's business plan in contexts of need, market size, competition level, competitive strategy, and marketing plans.

In order to realize its full potential and maximize its value, Peapod will expand as quickly as possible to attractive markets in order to preempt competition and gain first-mover competitive advantages in these markets. With this in mind, the Company has made "portability" of the Peapod system and establishment of long-term strategic alliances a top priority.

Financial Strategy

Peapod's primary financial objective is to generate substantial financial returns to the Company's shareholders who are willing to

assume the risks associated with providing capital to Peapod during the early stages of its existence.

In order to accomplish this objective, Peapod has made and will continue to make every effort to preserve cash every step of the way and to expand its operations with internally generated funds to the extent possible. Accordingly, Peapod closely monitors its cash needs on a weekly, monthly, and quarterly basis. To the extent Peapod finds a cash shortage on the horizon, Peapod is prepared to issue equity in order to maintain the financial flexibility required to achieve the company's long-term strategic objectives.

Capital Needs and Use of Proceeds

Having raised a total of \$400,000 from the Evanston Business Investment Corporation, Northwestern University Technology Commercialization Center, and private investors, Peapod is seeking to match this amount of capital to: 1) complete development of the Apple Macintosh version of the Peapod software which management expects will significantly increase the number of Peapod households; 2) continue developing market research products and systems which are expected to generate \$350,000 in very profitable revenues during 1992; and 3) begin expansion of Peapod both throughout Chicago and into other cities.

Projected Financial Statements

Peapod's projected balance sheet, income statement, and cash flow statement for the years 1991-1995 are detailed in exhibits 2-4. A comprehensive financial analysis and review of assumptions are available upon request and as part of the company's Private Offering Circular.

Results

According to A. Parkinson,⁷

Peapod recognizes it must invest money to grow to a point at which it will be profitable (i.e., through investment spending). During the first two full years of existence (1990 and 1991), Peapod invested its cash in developing and refining software systems, while confirming the demand for its product among consumers. Peapod reported negative earnings for both of these years. Peapod anticipates that it will continue an investment spend strategy for one to two more years (beyond 1992) before it becomes profitable. Overall, Peapod will have operated four years as an investment spending or non-profitable company, followed by years of projected high margin profitability.⁷

Exhibit IV.2. Projected Earnings By Year²
(in thousands of dollars)

	1991	1992	1993	1994	1995
<u>Sales</u>					
Software Sales	3	391	794	2,270	4,818
Annual Membership Fees	5	301	857	2,446	5,817
Grocery Related Fees	26	548	2,442	7,521	19,950
Modem Sales	6	74	150	430	911
Market Research (ICM) Sales	15	350	3,300	10,920	22,690
On-line Advertising Sales	1	25	522	1,491	3,737
Additional On-line Service Fees	0	0	352	1,006	2,523
 Total Sales	 56	 1,689	 8,418	 26,084	 60,446
 <u>Cost of Goods Sold</u>					
Software	1	25	80	227	482
Modems	4	58	118	339	719
 Total Cost of Goods Sold	 5	 83	 198	 566	 1,201
 Total Gross Profit	 51	 1,606	 8,220	 25,518	 59,245
 <u>Operating Expenses</u>					
Grocery Expense	36	302	1,544	5,189	14,140
Zone Overhead Expense	28	307	877	2,718	5,910
City Overhead Expense	88	383	1,244	3,233	7,286
Corporate Overhead Expense	145	539	836	1,269	2,198
ICM Overhead Expense	38	370	1,010	2,406	4,520
Depreciation Expense	56	302	729	1,873	3,878
 Total Operating Expense	 391	 2,203	 6,240	 16,688	 37,932
 Income from Operations	 (340)	 (379)	 1,980	 8,830	 21,313
Interest Expense	19	68	155	398	844
Earnings Before Taxes	(359)	(447)	1,825	8,432	20,469
Taxes	0	0	730	3,373	8,188
 Net Income	 (\$359)	 (\$447)	 \$1,095	 \$5,059	 \$12,281

Exhibit IV.3. Pro Forma Balance Sheet (Projected)²
(in thousand of dollars)

	1991	1992	1993	1994	1995
Assets					
Current assets:					
Cash and equivalents	\$ 191	686	1,711	6,600	19,444
Accounts Receivable	4	130	648	2,006	4,650
Inventories	0	6	12	33	70
Other Current Assets	21	21	21	21	21
Total Current Assets	216	843	2,391	8,661	24,185
Property and equipment	210	879	2,249	5,839	12,731
Less Accumulated Depreciation	(71)	(373)	(1,102)	(2,975)	(6,853)
Net property and equipment	139	506	1,147	2,864	5,878
Other Assets	10	10	10	10	10
Total Assets	\$ 365	1,359	3,548	11,535	30,073
Liabilities and Shareholders' Equity					
Current liabilities:					
Accounts payable	16	188	774	2,376	6,238
Total current liabilities	16	188	774	2,376	6,238
Long-term debt	129	399	907	2,232	4,627
Shareholders' equity:					
Common Stock	694	1,694	1,694	1,694	1,694
Retained earnings	(474)	(921)	174	5,233	17,514
Total Shareholders' Equity	220	773	1,868	6,927	19,208
Total Liabilities and Shareholders' Equity	\$ 365	1,359	3,548	11,535	30,073

Exhibit IV.4. Projected Cash Flow Summary²
(in thousands of dollars)

	1991	1992	1993	1994	1995
Cash Flows from Operating Activities:					
Net Income	(\$ 359)	(447)	1,095	5,059	12,281
Adjustments to reconcile the net income to net cash provided by operations:					
Depreciation	56	302	729	1,873	3,878
(Increase) decrease in receivables	(4)	(126)	(518)	(1,359)	(2,643)
(Increase) decrease in inventories	0	(5)	(6)	(21)	(37)
Increase (decrease) in payables	(13)	172	586	1,602	3,862
Net adjustments	39	342	792	2,095	5,060
Net Cash Provided by Operations	(321)	(105)	1,886	7,154	17,341
Cash Flows From Investing Activities:					
Equipment purchases	(141)	(669)	(1,369)	(3,590)	(6,892)
Net cash used in investing activities	(141)	(669)	(1,369)	(3,590)	(6,892)
Cash Flows From Financing Activities:					
Proceeds from long-term borrowings for equipment	71	335	685	1,795	3,446
Principal payment on long-term debt	(13)	(65)	(177)	(470)	(1,052)
Sale of common stock	500	1,000	0	0	0
Net cash provided by financing activities	557	1,269	508	1,325	2,395
Net Increase (Decrease) in Cash	96	496	1,025	4,889	12,844
Cash and equivalents, beginning of year	95	191	686	1,711	6,600
Cash and equivalents, end of year	191	686	1,711	6,600	19,444

Discussion

*Interview with Thomas L. Parkinson, Vice President, Peapod Delivery Systems Inc.*⁸

Mr. T. Parkinson: Peapod was started by my brother and me about two years ago. The idea was simple. We wanted to provide a mechanism by which individuals could order groceries, and have the items shipped and delivered to the house the same day. We aim to be the "Federal Express" of the grocery delivery service. My brother, the president, runs the business side and marketing. I'm responsible for the technology, the operations, and the systems, making sure the business "works."

In reality, software design is like sculpturing. It's an art form. The thinking process is abstract. And you won't find people in software tech-

nology who are old. With Steven Jobs and Alan Wozniak, PCs began in 1981. That's only ten years ago. In designing our system, our product, I was able to apply my training and ability in sculpturing and in art. That's one of the reasons I am enjoying this experience so much.

The software that we market, Peapod, represents distributed or parallel processing. Our technology is "leading edge." The PCs, which our customers use, become part of the system when our software is introduced. Our customers cannot only shop, they can call up information, and make selective, intelligent decisions as a result of that information. They can sort by price and identify specials which are current. They can look at the current Jewel/Osco flyer for the week. They can shop from a personal shopping list or can give the system power to select and shop in order to maximize savings. The system estimates the total cost to the consumer and permits a review of the entire order before executing. Customers can indicate when they want delivery. Delivery is now (in 1992) being made at a charge of \$3.95 plus four percent of the total grocery sale.⁹ The shoppers and the drivers are paid by Peapod. Each customer has a PC password to maintain security.

Interviewer: Considering the people you're associated with, and the innovations you are seeking, what do you feel helps individuals to be creative in your environment?

Mr. T. Parkinson: A lot of freedom is important—an environment of freedom. By freedom, I mean to be free to make your own hours, to work at home on a computer, those kinds of things. If individuals are meeting their quarterly goals, we don't care if they come in or not. They don't have to ask permission. They only need to call in and let us know where they are. But, of course, "bottom line" people have to be here, in the office. I'm here long hours.

Sometimes we have to be "hard" about individuals meeting their goals. You get freedom but you have to deliver. Goals are kept to the

minimum, but they need to be accomplished. I strongly believe that goals should not be day-to-day, not even week-to-week, in terms of measuring their completion. A lot of things happen on the way to achieving goals. And technical people tend to go through bursts of activity and accomplishments. Accordingly, we have quarterly goals. Sometimes it may appear that individuals are not doing work. This appearance can almost seem like laziness. And then they work in bursts. But, none of this applies to me.

I'm an entrepreneur and that overrides everything. Motivation as an employee is different than motivation as an entrepreneur.

We also stress freedom in *how* individuals do things, but not in *what* they do. By that I mean that the work has to be structured in terms of results. We need to meet the objectives of our business. So there are specific guidelines on what needs to be accomplished.

In considering creativity, it is important to recognize that implementation is very important. All members of a business need to be creative *and* be able to implement their ideas. Something that I try to do, in helping our people, is when they request new products or new software, I try to say yes immediately. If enhancements are used to make better products or services, the added expenses will pay for themselves many times over. Such enhancements make the work more enjoyable, and they motivate people. We only expect that common sense will be used in considering any acquisitions.

Interviewer: Drawing upon your distinctions, what do you feel enhances one's ability to be successful as an *entrepreneur*?

Mr. T. Parkinson: It's easier to talk about dangers in entrepreneurship. First of all, burn-out is a threat. I got sick from working so hard. So, I have to take breaks.

Another related problem arises because I'm not sitting back enough. I try to take the pressure off the technical employees. I take "heat" all day long, so my programmers are left alone. I feel that

technical people need peace to think and opportunities to respond quickly, without unnecessary distractions. In my own case, I don't get enough time to be creative. Needs vary. I have to respond to the needs, whatever they are. But, I get creative when I go away, like on trips.

Let me add some further points on management. We believe that staff meetings are important, but that they shouldn't be held too frequently. We have quarterly meetings, which involve the eight people making up our full-time employees. That includes the two principals. Considering part-timers, we have 35 employees, overall. There are also formal meetings of key individuals every two weeks to review progress and adjust strategies.

As an organization grows, I don't see that the management of technical people has to shift. We want to maintain the quarterly goals, but also want to keep our environment as a "fun place." We feel that as long as our basic rules are followed, we can allow latitude in other areas. So we have published an employee manual, actually two versions, one for office people and one for our drivers and shoppers. It was drawn from the ideas embodied in manuals from larger firms, but was reviewed with our employees before adopting it. So, as you can see, while we try to be somewhat informal, we recognize that we are running a system of operations. To do that effectively, we focus on building a suitable culture which emphasizes organization and performance.

We also believe that performance on the job is what is important. Accordingly, our rules governing drugs and drinking are very strict on the job, since actions by employees reflect on the company. We also recognize that what individuals do on their own time is their business.

The hardest part of our business, the entrepreneurship, is the possibility of running out of money. We know that unless certain things happen, we will run out of money in six months. If that happens, what do you do? Investors have

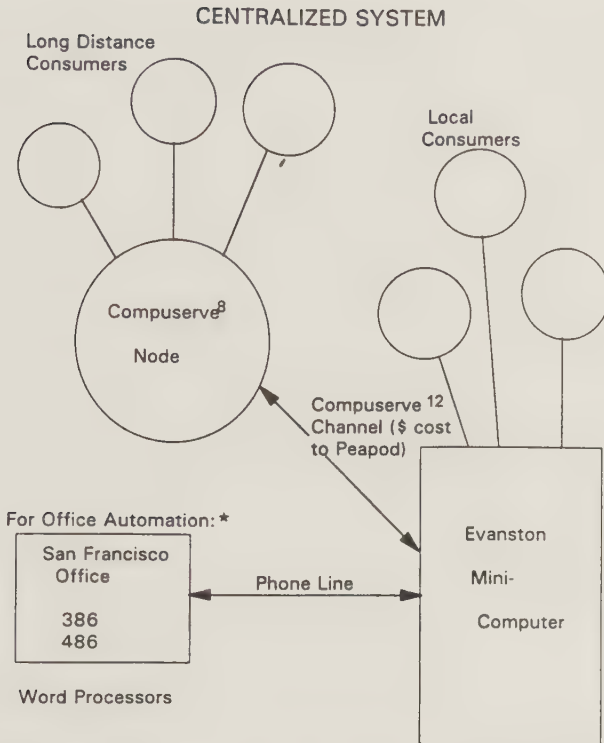
put hundreds of thousands of dollars into our business; so there's a lot of pressure. The clock keeps ticking. We do everything we can to keep the burden off of our employees. Some employees are taking salary in stock. But principals are not taking money out of the business at the present time. So, there is a lot riding on what we do.

We are optimistic. We have about 500 customers in the North Shore area now. When we are ready, we will go Chicago-wide. Our expectation is to break even after our third year of operation.

I must admit, given the pressures, there are times when you just want a 9-to-5 job. Both my brother and I are in our early to mid-30s. He has a wife and child. In our present mode, we seem to be constantly "poor." But, we also know that the idea for our business is very good. The problem is cash management. We also know that, perhaps, our greatest growth will come from marketing research and as a vehicle for promoting and distributing the products of consumer products firms. We are looking to see what else we can do given that \$5 per delivery doesn't permit us to make much money. But, we could replace the "milkman" in every aspect. So we are looking at ways of expanding our concept and services. We regard ourselves as a hub with spokes. It is a simple matter to add new "spokes" to our operations.

Interviewer: Is there any competition for this type of service?
Mr. T. Parkinson: *PRODIGY*¹⁰ used to be in the business, but they dropped out. We don't feel that we have any competition at present, so we have a window of opportunity.

Interviewer: What questions are you pondering at the present time, as the coming year begins to unfold?
Mr. T. Parkinson: Our first question, which is fundamental, relates to how we capitalize our business, long term. Do we continue to raise money and corporately own everything in the business, or do we franchise Peapod satellites and sell these to individual owners to raise money? That decision impacts on



Note: * PCs would basically be running a local office. Customer PCs would be dialing into Evanston.

Exhibit IV.5. Mapping of a Centralized System at Peapod

our entire operations. For example, considering technology, do we simply keep one computer and lease lines to nodes? We could then work with a central computer operating through a computer service company. Do we pay for long distance lines or lease them? Do we have short or long-term arrangements?

The answers to these questions depend on the size of our customer base, so that's a key variable. If we franchise, does each city have a Peapod center with 20-40 zones¹¹ that we operate through? So, the strategy of franchising versus owning outlets must be decided. And related to that is the decision of what kind of a network are we to create as we expand into other regions?

If we operate through a *central computer*, customer PCs would be dialing into our central mini-computer in Evanston (Exhibit 5). One computer would be expensive, but we would be “subsidizing” people who call through *Compu-serve*.¹² As volume increases, the rates charged by *Compu-serve* would increase. If rates increase, the centralized system could become prohibitively expensive. But from another point of view, and particularly when volume is small, it may appear better to be centralized. The computerized approach of a central system permits better cash flow. Software problem solving would be done at headquarters in Evanston. We would have better control over what is happening. We are conducting studies and analysis to resolve these issues. Various assumptions are being made in conducting the analysis.

Mr. T. Parkinson: Exhibit 6 represents a mapping for a *decentralized system* of expansion. In decentralized operation, a large mini-computer estimated to cost \$70,000 is required in each city. More specialized people would be required in managing the local offices than would be the case in centralized operation. But with those higher manpower costs, service may be better in the decentralized system. We need to do further analysis to resolve these possibilities.

The second question that we have relates to the PC which we adopt, again long term. Presently we are operating through IBM-compatible systems. Do we develop the system for the Macintosh PC?¹³ Do we spend money for that development now or defer that decision, while opening up a second zone of operations in expanding our business? If we expand to include the Macintosh PC, the estimated costs would be \$75,000-\$100,000 for hardware, software, and a programmer. We would get more members (maybe 500 more) in a zone and that would increase “zone density.” But the costs incurred would delay opening up a second zone, which could supply 1,000 new members for the same investment in a zone. This may be a “judgment call.”

DECENTRALIZED SYSTEM

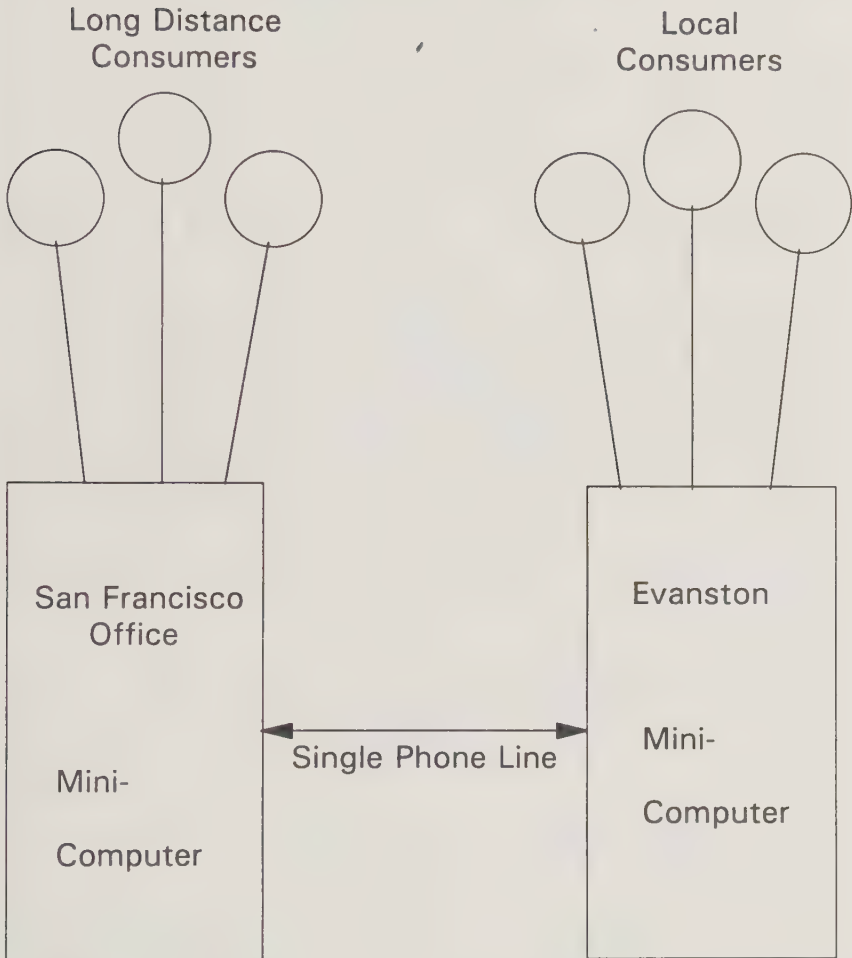


Exhibit IV.6. Mapping of a Decentralized System for Peapod

The third question relates to the type of involvement (the principals have) in running our business, as it evolves. Do we continue to retain close control or do we turn the business over to professional management—and at what point do we do that? Do we even want to do that?

As an entrepreneur, I want to do something significant for mankind, which will be recognized as such. I very much enjoy the process of being an entrepreneur. I would even enjoy doing it again. I have a big ego and am "hyper." But, I have to deal with the aspect of risk. And I don't like criticism. And I still wonder if I should go back to a regular job where I could make a very large salary, right now.

CASE NOTES

1. Communication with Andrew B. Parkinson, president of Peapod Delivery Systems, Inc. (PDSI), January 11, 1992. Peapod, L.P. is a trademark of Peapod Delivery Systems, Inc.
2. The business plan of PDSI was provided on October 8, 1991 by Thomas L. Parkinson for use in preparing this case, and is reprinted with some editing.
3. Peapod has received excellent "press" on its operations. For examples, see: Cheryl Jackson, "Peapod grows in at-home grocery shopping," *Chicago Tribune*, Business Section, pp. 1,4 (June 26, 1991); Michael Fitzgerald, "A Jewel in the on-line service," *Computerworld*, Vol. 34, No. 7, p. 66 (September 10, 1990); Steven Pratt, "The Market: 3 grocery giants, 1 entrepreneur, launch shop-at-home schemes," *Chicago Tribune*, Section 7, p. 10 (March 14, 1991).
4. From: Ron Alexander, "New Yorkers, etc.: What chore do people hate the most? Despite a crowded field, the winner has no competition," *The New York Times*, p. 40 (September 30, 1990).
5. The stated prices are as of January 1992 and are subject to change.
6. UNIX is a registered trademark of Novell, Inc. in the United States and other countries, licensed exclusively through X/Open Company, Ltd.
7. The note on "Peapod Results" was provided by Andrew B. Parkinson in February 1992.
8. The interviews with T. Parkinson were conducted on September 2 and October 8, 1991.
9. Total grocery sale = dollar amount at the cash register. This pricing is as of January 1992 and may vary with time and location.
10. *PRODIGY* is a registered service mark and a trademark of Prodigy Services Company.
11. A zone is a store delivery area. Each city must have 30 zones.
12. *Compuserve* is a trademark of Compuserve Incorporated.
13. Since DOS-compatible Macintosh or Apple PCs became available, as indicated in 1994, this issue of IBM versus Apple computers became less substantive than was the case earlier, depending on the willingness of potential users to upgrade their equipment. Macintosh and Apple are registered trademarks of Apple Computer, Inc.

CASE 5. DEAN FOODS COMPANY: *EASY* 2%¹

On May 2, 1990, Dean Foods Company introduced *Easy* 2% Lowfat Milk. According to Howard M. Dean, chairman and CEO of Dean Foods, "our research revealed that many people who had trouble digesting milk still loved the taste and wanted to reap its nutritional benefits. We developed *Easy* 2% for these consumers, but we think it tastes so good, the entire family will enjoy it."²

Dean Foods Company, based in Franklin Park, Illinois, is the second largest fluid milk processor in the nation with annual sales reaching \$2.2 billion by May 26, 1991. The company is a publicly held Fortune 500 company which, according to the Overview in the 1991 Annual Report:

distributes a full line of dairy products, including fluid milk, ice cream and other fresh and extended shelf life products, plus a diversified mix of specialty food items, including canned and frozen vegetables, pickles, powdered coffee creamers, sauces, puddings and dips. Products are retailed under Dean's family of brand names and under private labels throughout supermarkets and specialty food stores nationwide and are sold to foodservice distributors and outlets and industrial bulk packagers both domestically and abroad.³

A steady stream of acquisitions of regional dairies has contributed to the extraordinary growth of Dean Foods Company. A listing of products, operations, and acquisitions, as of 1991, follows.^{3,4}

PRODUCTS AND OPERATIONS OF DEAN FOODS COMPANY⁵

(As of 1991)

PRODUCTS:^{3,4}

Fluid Milk: A full line of fresh products, including homogenized, low-fat and skim milk, *Easy* 2%, cottage cheese, yogurt, half and half, buttermilk, chocolate milk, sour cream, and juices, marketed under strong regional brand names.

Ice Cream: Packaged ice cream, sherbets, frozen yogurt, and frozen novelties, distributed under private labels and regional labels, including *Dean*, *Fieldcrest*, *Gandy's*, *Creamland*, *Bell*, *Price's*, ...*Mayfield*, ...and *Light* brands.

Natural Cheeses: Aged cheddars and other natural cheeses, including retail brands used by McCadam Cheese Company (*McCadam* and *Yankee*).

Canned and Frozen Vegetables: A full line sold nationally and overseas under the *Freshlike* and *Veg-All* brands as well as under private labels.

Pickles, Relishes, and Salad Dressings: Principal brand names include *Peter Piper*, *Heifetz*, *Pesta*, *Atkins*, *Ma Brown*, *Whitfield*, *Hoffman House*, *Cates*, *Aunt Jane's*, *Tree*, *Rainbo*, *Daily*.

Powdered Products: Primarily non-dairy coffee creamers, sold to national and international users.

Sauces, Puddings, Dips, and Salads: Includes Dean's low-fat sour cream and Mrs. Weaver's line of salads.

DFC Transportation: Some 385 tractors and 700 trailers haul products and materials across the country for Dean's Divisions and for a number of well-known food and other companies.

REGIONAL OPERATIONS AND ACQUISITIONS (from 1950 forward, including starting dates with DFC).^{3,4,5}

Dean Milk Company (Louisville, KY, 1950); **Dean Foods** (Monticello, IN, 1960); **Liberty Dairy Company** (Ewart, MI, 1965); **Fieldcrest** (Westby, WI, 1966); **Bowman** (Louisville, KY, 1973); **Gandy's** (San Angelo, TX, 1976); **St. Thomas Dairies, Inc.** (St. Thomas, Virgin Islands, 1978); **Creamland** (Albuquerque, NM, 1978); **Bell Dairy Products** (Lubbock, TX, 1978); **Price's** (El Paso, TX, 1978); **McArthur Dairy** (Miami, FL, 1980); **T.G. Lee Foods** (Orlando, FL, 1980); **Dean Dairy Products** (Sharpsville, PA, 1984); **Gilt Edge Farms** (Norman, OK, 1984); **Hart's** (Ft. Myers, FL, 1985); **Reiter** (Akron, OH, 1986); **Ryan Milk** (Murray, KY, 1986); **Verifine** (Sheboygan, WI, 1987); **Fairmont Products** (Belleville, PA, 1987); **Ready Food Products, Inc.** (Philadelphia, 1990); **Mayfield Dairy Farms** (Athens, TN, 1990); **Cream o'Weber** (Salt Lake City, UT, 1991); **Meadow Brook** (Erie, PA, 1991).

Selected Financial Information

Dean Foods Company (DFC) has had a long period of consistent growth and profitability.³ For the 18-year period from 1973-1991, the company has seen its annual sales, net income, and earnings per share reach record highs. The company is widely recognized for its excellence of management.^{5,6,7,8}

In their letter to shareholders in 1991, Dean and William D. Fischer (president and chief operating officer) highlighted the company's strong financial performance. It was noted that earnings reached \$1.79 per share in 1991 (an increase of 17% compared to 1990), that net sales passed the \$2.1 billion level for the first time in the company's history, that capital expenditures for plants and distribution systems reached \$72.8 billion, and that several strategic acquisitions (e.g., Meadow Brook Dairy Company with plants in New York and Pennsylvania) strengthened the company's base business (Exhibits IV.1 and IV.2). Within the 1991 annual report, it was stated that: "Our continued success with fluid milk products warranted significant capital expenditures during the year which will permit further growth. . . . As a result, Dean's products continue to adhere

Exhibit IV.1. Summary of Operations of Dean Foods Company and Subsidiaries

<i>In thousands except of items marked with an asterisk</i>	<i>1991</i>	<i>1990</i>
Operating Data		
Net Sales	\$2,157,997	\$1,987,517
Costs for products sold and all operating expenses	\$2,022,092	\$1,876,176
Interest expense	16,780	12,682
Income before taxes	124,340	102,06
Provision for income taxes	51,807	40,834
Net income	72,844	61,232
Net income as a % of sales	3.4%	3.1%
Depreciation on properties	44,465	37,338
Capital expenditures	72,844	68,196
Number of employees	9,600	8,900
Balance Sheet Data		
Working capital	198,429	182,852
Total assets	816,999	744,759
Net plant and equipment	375,930	337,068
Long-term obligations	149,980	146,622
Shareholders' equity	416,560	362,760
Return on average equity	18.6%	18.7%
Common Stock Data		
Net income per share	1.79	1.53
Cash dividends per share	.49	.44
Book value per share	10.23	8.93
Number of shareholders	8,380	8,005

Source: 1991 Annual Report of Dean Foods Company, p. 34.

to the highest quality standards" (p. 6). The lactose-reduced milk, *Easy 2%*, was considered to be winning acceptance among lactose-intolerant consumers who have responded favorably to the product's "fresh milk taste" (p. 6).³

Financial results reported through the third quarter of 1992 by Chairman Dean indicated that 1992 was a more difficult year than 1991 for the company. According to Dean,

Earnings for the *nine months* ending February 23, 1992 were \$46.6 million compared to \$49.2 million last year (1991). . . . Sales for the nine months were \$1.65 billion compared to \$1.59 billion last year. The third quarter decline in earnings was the result of lower dairy margins due to increased competitive conditions and raw milk costs substantially higher than a year ago. . . . Given the present economic climate facing both segments of our business (Dairy Products and Specialty Food Products), it is unlikely that fourth quarter earnings will exceed last year's record levels. While a decline in annual earnings after eighteen consecutive increases is disappointing, our underlying businesses remain sound. Record unit sales volumes and favorable cash flows are being achieved during a difficult year and our strong financial position provides the capacity for growth, both internally and through acquisitions.⁹

Exhibit IV.2. Business Segment Information for Dean Foods Company (1991 and 1990 Data, Fiscal Years Ended May 26)

<i>(In thousands)</i>	<i>Dairy Products</i>	<i>Specially Food Products</i>	<i>Corporate and Other*</i>	<i>Consolidated</i>
1991				
Sales	\$ 1,323,161	\$ 742,063	\$ 92,773	\$ 2,157,997
Operating earnings	86,575	69,850	(32,085)	124,340
Identifiable assets	371,396	361,458	84,145	16,999
Depreciation and amortization	28,204	16,137	2,627	46,968
Capital expenditures	42,635	28,908	1,301	72,844
1990				
Sales	\$ 1,250,172	\$ 656,419	\$ 80,926	\$ 1,987,517
Operating earnings	50,065	76,087	(24,086)	102,066
Identifiable assets	353,401	312,387	78,971	744,759
Depreciation and amortization	24,136	12,467	1,999	38,602
Capital expenditures	35,012	30,793	2,391	68,196

Note: "Corporate and Other" includes revenues and expenses of the Company's transportation subsidiary and canned meats processed under government bid contracts. General corporate expenses, interest expense, and interest income are classified as "Corporate and Other." Identifiable assets are those used in the Company's operations in each segment.

Source: 1991 Annual Report of Dean Foods Company, p. 30.

Interviews of Key Individuals

In order to tap into an understanding of the *Easy 2%* project, several interviews were held with key participants in late 1991 at the Rockford, Illinois facility and at headquarters in Franklin Park, Illinois. The individuals interviewed were:

George A. Muck—Vice President, Research and Development,
 R. Scott Rambo—Director of Research,
 Ron Rahorn—Food Scientist and R&D Section Leader for the Dairy Products Division,
 Dave Rotunno—Director of Marketing and Advertising, Dean Foods Company.

Interview with George A. Muck, Vice President, Research and Development, Dean Foods Company

Dr. Muck: Given that we are trying to get a product on the market, and to be successful in that regard, our R&D interests are much more focused than is the case at

universities. The story on *Easy 2%* illustrates that focus and the nature of what we do. Most of the issues in this case will be in the marketing domain, involving the questions of how do we get the product to grow in the marketplace?

The *Easy 2%* project originated because a certain proportion of the population is intolerant to the lactose, which is naturally present in milk. Lactose intolerance can exist in certain minority groups, such as Asians or Blacks, to a larger extent than the general population. Or it can arise when people have stopped drinking milk for long periods of time. So, it is a condition which usually occurs more with adults than with children.

When lactose intolerance occurs, the specific enzyme (lactase dehydrogenase) does not split lactose into two parts (the simple sugars). If the splitting of lactose doesn't occur, milk can give cramps and indigestion. We estimate that as many as 20 percent of the total population may be susceptible to this unpleasant condition. That figure may be high, but it represents our motivation in starting this project.

Prior to the existence of *Easy 2%*, other products were available, but they had certain shortcomings. For example, we had been making a product by UHT (ultra high temperature) processing, which converted the lactose in milk. One of our plants still runs this product. It has a distinct cooked flavor. So, we said we wanted a product which tastes more like fresh milk. Flavor, cost, and container size are the three important criteria for this product.

Our product, *Easy 2%*, has a more appealing flavor and meets all the pertinent criteria. But it doesn't have as wide a distribution, or as high a sales level as we would like. That is the problem we want to address.

I believe it is useful to consider the past history of the project, and how it evolved, to understand the technology which is embedded in this product. A critical issue in the project was the choice of enzyme used to hydrolyze the lactose to its simpler sugars. In our early work, we recognized that the initial lactase enzyme available might cause off-flavors. We

investigated additional sources of lactase, and we selected the one which is very high in purity. An arrangement has been made for its supply. Although there is potentially a high volume of usage, the product hasn't reached its potential in the marketplace. That's a problem because possible discounts from our supplier depend on the volume of use. We can't achieve the desired levels of discount without reaching the higher sales volume. However, we have established the best enzyme and have found the flavor to be as good as that of regular two percent milk. *Easy* 2% is only slightly sweeter than the regular milk.

The medical literature says that 70 percent of the lactose has to be hydrolyzed to meet the criterion of digestibility. So, we have relied on that input. We also found that it is desirable to control the level of hydrolysis closely around the 70 percent level, to avoid having a product which is too sweet. We decided to control the hydrolysis in the range of 70-72 percent, inclusive. We are also constrained by time. Higher levels of hydrolysis would require longer processing times. That also would increase cost to the consumer, so processing time is to be kept at a minimum.

In processing, we start with regular whole milk. Two avenues are then possible. We can treat milk on the "raw side" or after pasteurization. In the latter approach, we would be adding the hydrolyzing enzyme after pasteurization. The dairy industry, including the FDA, has frowned upon adding the enzymes afterwards, because of the possibility of contamination. Also, if we add the enzyme afterwards, we can't control how far the hydrolysis goes. So we work on the raw side. R&D had to make this decision and recommendation, and to work with marketing to check and control product flavor. Pasteurization inactivates the system, stopping further hydrolysis, so it represents a good method for controlling the process. On the raw side, temperature control is critical. We decided to conduct the hydrolysis at 40° F, that is, at a cold temperature. We determined the amount of enzyme to add, then the amount of time required to reach the 70-72 percent

range of hydrolysis. (By this time, the quality of the enzyme had become a constant). When values for all the important variables were defined, we then introduced pasteurization to stop the reaction. We then went from the lab to the plant to confirm the results. There were no further problems, so we were able to proceed into the marketplace without delay. We did not require special permission from the FDA because it was already an approved product, and we hadn't altered the product significantly.

Interviewer: It sounds like the project was not too difficult, and it ran smoothly.

Dr. Muck: Yes, but after the initial production, the product was not selling well. We were asked by marketing to lower the cost of the product so its selling price would not be significantly greater than that of regular two percent milk. That request required additional work. We did studies and found that the level of enzyme in the process could be reduced in arriving at a lower cost. The level of enzyme is the biggest factor in determining cost of the finished product. In lowering the enzyme level, we found it necessary to substantially increase processing time. Manufacturing had to agree to permit a much longer processing time. Production said yes, we can do it. We are fortunate to not have adversarial relations with any of the other functions, such as production or marketing. So our manufacturing time is running longer now.

Interviewer: From the perspective of the vice president of R&D, how would you categorize this project? How satisfying has it been for you?

Dr. Muck: From a technical point of view, I regard this project as a good one for us. We felt that the product was very doable. It was interesting, exciting, and rewarding, as an experience. However, on the other side of the coin, from the marketing point of view, I wasn't sure how marketing would relate to the product.

Interviewer: Whose idea was the product?

Dr. Muck: Actually, marketing people came up with the idea. They were concerned about the "20 percent of the population" who couldn't handle milk. They

perceived the idea as an opportunity but also as a problem. By introducing the product, they wondered if they would also be suggesting to people that there might be something wrong with regular milk. There could be a negative reaction. That was the negative side of the issue. After considerable discussion, a policy decision was made consistent with the notion that any negative would be far outweighed by the positives of the product. So, the decision was made to proceed with the development. We agreed with the decision.

We also have a marketing and R&D committee that meets with management on a quarterly basis. That's another forum in which matters such as *Easy 2%* are aired and discussed. In such meetings, R&D tries to objectively point out the pluses and minuses surrounding an issue. We also develop legal issues as we see them. If an FDA regulation is involved, we take a firm stand. Otherwise, the marketing decisions are made by marketing. In general, marketing tends to be more aggressive; we tend to be more conservative in making decisions.

Interviewer: On an arbitrary scale of 1-10, where 1 is nil and 10 is extremely high, how would you rate the importance of *Easy 2%* to the business of Dean Foods.

Dr. Muck: Business-wise I'd give it a "6." The score is relatively low because of the question of how do we convince people there's a need for this product. In relation to our department, R&D, I'd score it an "8." We said the product was achievable and we accomplished all that was asked of us.

Interviewer: How is your company organized in terms of structure?

Dr. Muck: We don't publish any organization charts, but we are functionally organized. There are no artificial boundaries. R&D consists of some 20 individuals and is centralized at Rockford, Illinois. There is very little R&D done in local divisions. R&D specialists focus on divisional matters as required.

Our method of operating is very informal. We build and maintain excellent and friendly relationships throughout our company. The emphasis is on cooperation and constructive problem solving. The

success of our company derives from the quality of our products and, equally, from the quality of our people and the relationships we have built.

Interview with R. Scott Rambo, Director of Research and Development, Dean Foods Company

Dr. Rambo: *Easy 2%* represents a good project. A case study of this project is representative of what we do in R&D at Dean Foods. Most of our product development projects come from marketing channels. The only exceptions to that occur when new technologies are involved. In the case of *Easy 2%*, we knew some individuals couldn't drink milk because of the discomfort that resulted. We had an earlier product from an ultra high temperature process, but it had a heated flavor from high heat processing. So there was a need. The project arose from marketing interest, but also from technology available. We had an opportunity way back. The opportunity came in 1987 when we ran across a continuous process for utilizing a lactose-reducing enzyme. The process involved an immobilized enzyme on a column. Our company investigated the process. The product recovered from the process was very "clean." But, there were some significant problems. There were hazards in cleaning up the column between runs. If the method of sanitation was not perfect, the column could be damaged with very substantial costs resulting. So, because the process was "touchy" and expensive, we didn't want to use this enzyme system. As a result, we began to look at other enzyme systems, which were available from various suppliers. Marketing began to feel that, if we could have good quality and could reduce cost, there would be an opportunity for a new product for the company.

There were some technical parameters which are pertinent for this project. According to the pasteurized milk ordinance, any claim of lactose tolerance must involve at least 70 percent hydrolysis, in order to meet legal requirements. On the other side, if you continue to hydrolyze lactose

beyond the 70 percent level, it becomes too sweet. So we, and marketing, knew at the outset that we needed to keep the level of hydrolysis of the lactose within a very tight range if we were going to be able to market the product.

A key development in the project was the identification and selection of a high quality enzyme. After screening candidates from several suppliers, we selected one which yielded a good flavor. The selected enzyme was also higher in activity so we were able to use a lower level in obtaining the desired results. We submitted samples to marketing and to sales managers and received favorable comments. Focus groups were conducted, with and without samples, to assess consumer reactions. We wanted to know whether the product could be mass marketed. Would it be able to find a niche? Was the flavor satisfactory? Concurrently, we were refining the product and moved into the pilot plant stage. The results continued to be favorable.

We also had to determine when to add the enzyme—before or after pasteurization. The finding that hydrolysis continued if the addition was after pasteurization led to the decision to add the enzyme *prior* to pasteurization. It was also found that the enzymatic action is time and temperature dependent, so these variables had to be explored and controlled. Since the end product, milk, requires refrigeration, we had to do the hydrolysis at 40 degrees Fahrenheit. Initially, the treatment was done for seven hours. After going into production, we were asked to run the process at a lower cost, so we reduced the enzyme in half and ran to a longer processing time, about 14 percent longer. As a result, the processing cost was substantially reduced, and the selling price could also be reduced.

Another project was to determine the effect of temperature on product quality, so we systematically explored the processing temperatures of 36, 38, 40, and 42° F. These resulting data helped us to set up in-process specifications that were reliable and meaningful.

And in another project, we examined the possibilities of "back-standardizing" and of blending, since we felt we couldn't always conduct the process all at once in a given production sequence.

We also needed a quick and reliable analytical method for determining the level of hydrolysis. By enzymatically determining the level of glucose, a hydrolysate product, we were able to complete an analysis within ten minutes time. That development was important because we could start quenching the hydrolysis at 68 percent by pasteurization, and then finish in the 70-75 percent range, without the need for back-standardization.

Interviewer: It sounds like you have done some good science in deriving the product. Have you published any of the results of these studies in technical journals?

Dr. Rambo: As a general rule, we don't publish papers. We just don't have the time. But, we are very thorough in conducting scientific investigations. We also don't generally patent our products. We don't want to tell the world, our competitors, what we are doing.

As a result of our studies, sales and marketing knew enough about the product to build a strong program of advertising and education. A target-date was set for the introduction. R&D was involved with the training of quality control specialists. The product was introduced into the market place in May 1990—three years after our original enzyme studies. After settling into the introduction, the base of sales volume was found to be lower than desired—although still acceptable. In my opinion, this product will continue to need strong marketing support, if it is to be successful. It is important to recognize that this product is a specialty product, *not* a commodity product.

Interviewer: Are there products which are competitive to your offering?

Dr. Rambo: Yes, the tablet *Dairy Ease* [a trademark of the Sterling Drug Company] represents a competitive product; but it is in a different form. As mentioned earlier, there is also an ultrahigh temperature (UHT) derived

product, in liquid form, but the flavor is not as satisfactory. So our product is presently the only one of its quality in low fat milk. But as we develop the market, we can expect other players to enter the market with similar products. Other dairies have the capabilities of doing this. But we have certain advantages, the advantage of being the first entrant, and the advantage of a solid relationship with our supplier for the key ingredient.

Interviewer: How did this project “go” relative to other projects?

Dr. Rambo: As director of research, in that role, I felt that the project went very well. It’s a good example of how a project ought to go. It took almost three years. There were good relationships throughout. We hit all targets relative to the introduction. The original technology began in R&D, when we picked up information on the continuous system. A little time was required for sales and marketing evaluation. Once samples, with improved flavor and quality and lower cost, were submitted to sales and marketing, they were quick to recognize the opportunity. So, we came together neatly.

Interviewer: What kinds of accountability do you have in R&D at your company?

Dr. Rambo: We don’t have to budget expenditures on a project/division basis. We do work for different divisions of Dean Foods. We do have a corporate budget which defines the total allocation for R&D. If we stay within total budget and meet our objectives, everyone is happy. We also have a capital budget which permits improvements in our technological base.

I came from another division and have been here (in R&D) for five years. The culture is very informal. That minimizes “paper shuffling” and the need for going to many meetings. We are informal and are focused properly. In my job, I try to make sure we avoid working on projects which are going nowhere. That’s very important because we are operating in a lean fashion. We have to prioritize projects and keep people informed about our efforts. In that regard, we publish a departmental report three times a year and detail progress on projects in an “abstract format.” The abstract format is one in which work

on projects is described in concise project summaries, with sufficient detail that the reader is able to understand what has been done. We also have annual performance reviews.

R&D is a function you can't put a "P&L" on. But, R&D has to keep management informed. I have a review with my boss once a year.

There are other avenues of communication as well. We participate at budget review times. We participate three times a year in joint meetings with marketing. These meetings are also attended by our chairman and our president. We also attend officers' meetings which are held three times a year and we attend the engineering and production meetings. And finally on a select basis, we prepare and distribute project status reports when we have achieved significant milestones.

Interviewer: It sounds like everything is nice and smooth. Do you ever have critical situations?

Dr. Rambo: Yes, we have some "touchy moments." For example, once when we changed the production cycle to effect an improvement, there was more "shrinkage" (a lower yield) in finished product volume than we liked. Everyone was involved on the problem because of its economic impact. The problem was solved by going to a different processing system.

But, even in problems such as these, we are pretty "low key." We operate informally. Everyone knows everyone else very well. There is mutual respect. It's the nature of our culture and our people. We recognize priorities and simply contribute. Sometimes things can go pretty slowly for example, when we are waiting for an FDA approval. But as a group, we are very patient and very persistent.

Interviewer: How important on a scale of 1-10 do you regard *Easy 2%*, in the general scheme of things.

Dr. Rambo: In terms of company-wide sales, I would have to give it only a "3," not a high rating. But, this one small project has given Dean Foods some recognition—some good public relations.

In terms of my own division I would give *Easy 2%* a "9." It was a nice clean project. In R&D, we don't always have a lot of winners. Our product life cycles

tend to go on “forever,” so we don’t have frequent opportunities to introduce new products. In light of that, it’s important to keep people interested. *Easy 2%* has done that for us.

Interview with Ron Rahorn, Food Scientist and Research and Development Section Leader for the Dairy Products Division, Dean Foods Company

Mr. Rahorn: I can fill in some of the details for *Easy 2%* since I have been involved with that project from its inception up to the present time. We developed the product in this facility. In looking back, I feel that the biggest event was that the company decided to mass market the product rather than to put it out as a special dietary product. That decision stemmed from marketing research. The key finding was that there were a large percentage of individuals who were lactose intolerant.

It is interesting how the project originated. One of the enzyme suppliers came to us about 10-12 years ago and tried to interest us in using enzymes to increase sweetness. They observed when lactose is hydrolyzed, sweetness is increased from 16 to 65 sweetener units. The technology was not new, but the idea seemed intriguing. However, at the time with the enzymes available, we found from our work that the flavor was not great, and the sweetness was not great. So interest diminished for a time.

About eight years ago, we learned that the Japanese had developed an enzyme which they could put on a column to induce hydrolytic conversions. The Australians developed a working unit which became commercially available. The process stimulated our interest so we rented a laboratory unit. It was a key step along the way. We tried the process by running different fats through the column. Enzymes on the column served as a catalyst. We found the column to be difficult to clean. The cleaning process was very critical. One could ruin a very expensive column if extreme care was not taken. We also experienced different degrees of hydrolysis and channeling in running the

process. So, it was "very touchy." We did not renew our rental and did nothing for a while. But, during this early activity, marketing became aware of the technology, and became interested in the possibility of bulk marketing a product.

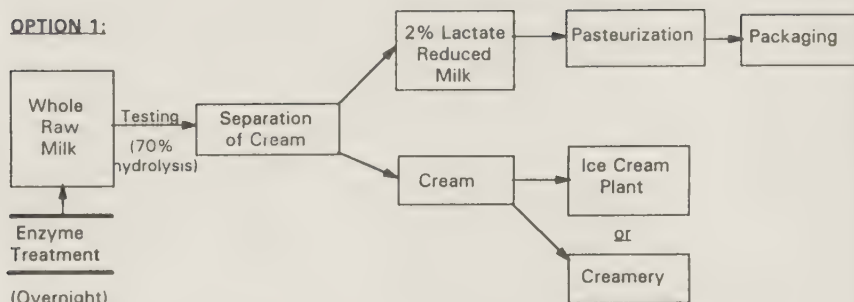
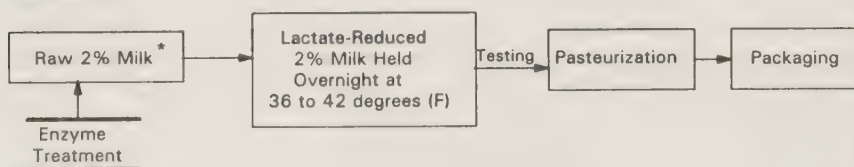
The company also had an ultra high temperature processing plant operating in Kentucky with the ability to reduce lactate. Because of the off-flavors produced, which you are aware of, sales were slow. It was assumed that this product would go out of date at some point.

So marketing continued to be interested in a reduced lactate product, and especially one they could market in gallon jugs. With that interest, we put more effort onto the project.

Interviewer: How long did it take to complete the R&D on the project?

Mr. Rahorn: A year of R&D effort was required to develop acceptable samples for marketing. The biggest challenge was to obtain a better enzyme system. Enzymes available, at the time, produced "barny" flavors. Finally a "cleaner" enzyme was available from a new supplier. The new enzyme was expensive; but at the time, cost had not been given to R&D as a parameter. That is typical of a new product under development. Initially, product cost is not a major consideration. And, as we noted for this product, there were plateaus of activity followed by more intensive effort as we continued on. Once we had the enzyme, we needed to define temperature, time, level, etc., in relation to the levels of hydrolysis that were achieved. The number "70 percent" became a "magic number" because regulations required that the product be 70 percent hydrolyzed in order to be designated "lactate-reduced."

Studies showed that pasteurizing after treatment with enzymes, in the batch process, was the preferred method considering flavor. Another question, which had to be answered, related to whether we treated whole raw milk (option 1) or two percent raw milk (option 2) in processing (Exhibit IV.3). Option 1, using whole milk, is the most normally run process at the present time.

OPTION 1:**OPTION 2:**

Note: * 2% refers to butter-fat content. Raw milk is prepared by blending skimmed milk with whole raw milk

Exhibit IV.3. Schematics of Processing Options for Easy 2%

The process best fits the layout of equipment in the plant. However, option 2, which involves treating two percent raw milk (after removal of cream), was found to be more efficient in the use of enzyme, so was it less costly. Option 2 is preferred, but will require changes in plumbing to permit its general use. Further cost reductions were also achieved by extending processing time and by using a lower level of enzyme.

Flavor panels, consisting of technical and non-technical people, were run by R&D in qualifying the various processing studies. These studies are typical of what we do in order to "fine tune" a process and minimize costs.

Interview with Dave Rotunno, Director of Marketing and Advertising, Dean Foods Company

Mr. Rotunno: The *Easy 2%* project was started three years ago. Marketing people here identified that a lot of people were lactose intolerant. The figures obtained from research were compelling (Exhibit IV.4). We were amazed at the low level of knowledge out there. There was low awareness.

Exhibit IV.4. Demographic Information

<i>Sector</i>	<i>% of Sector Estimated as Lactose Intolerant</i>
Asians	96 ¹⁰
Blacks	75
Hispanics	51
Caucasian	20

Source: Dean Foods Company.

That was attributed to a low level of education on the subject. People susceptible just knew they couldn't eat milk products.

Interviewer: Are the percentages really solid? They seem high.

Mr. Rotunno: We believe they are correct. So we felt there was a real opportunity here. At the time, there were some products available, but they were not very tasteful, and they were only packaged as quarts. We wanted to sell a milk product which was fresh and tasteful and available in 1/2 gallon containers.

The matter of taste has received considerable attention. As lactose is reduced, two simple sugars are generated. Above the level of 70 percent reduction, the milk becomes noticeably sweeter. With pasteurization, we can control the level to 70-75 percent. The product has a 14-day shelf life. At the fourteenth day, it's even sweeter than just after the reduction. So, we need to operate with fairly tight controls.

Our decision was to market a two percent milk product. One percent milk and skimmed milk represent the biggest growth areas in milk. Skimmed milk contains less than 0.5% butter fat. But, we find that two percent milk does taste better. Whole milk is in the range of 3.25-3.50 percent milk fat solids. Skimmed milk normally is not very palatable, but we are introducing a new better tasting product which we fortify with non-fat milk solids. The new product will be called "non-fat milk."

We presently are seeking a higher volume for the lactate-reduced products. We would like to see *Easy* 2% at four percent of total milk sales. The product hit a plateau at 1.5 percent, and now is at the two

percent sales level based on total milk sales. Initially, we invested about \$750,000 in advertising, and are now near a level of about \$1.5 million of total advertising dollars for this product. Our investment in advertising is higher than any other single product at Dean Foods. We knew it would be important to differentiate this product and to get across to the consumer the reason for using it. We have obtained good testimonial letters. People are drinking it and are enjoying it. We simply feel that not enough people are trying the product. That's the issue.

Our competition markets their product as "a drug." We didn't choose that strategy in order to avoid the costs of registration with the FDA. Also we don't consider the product as a drug. It is simply another form of milk which answers the need of a segment of the market place.

Easy 2% is about 20 cents/gallon higher in cost than regular milk. The present ranges of prices recommended to the consumer are listed in Exhibit 5. We find that above \$3/gallon (basis 1991) consumers tend to turn down *Easy 2%*. With major accounts, we don't do any promoting in order to keep our costs down. We do have in-store demonstrations (demos) and various public relations campaigns.

We will be a national processor for ultrahigh temperature-derived products. These products compete with *Easy 2%*. Tablets are also available from other suppliers. There is a tremendous mark-up for tablets.

Other low-lactose products are available, but very few, for example, sour cream, ice cream, and cottage cheese. Fat-free ice cream or frozen yogurt avoids the problem. It is interesting that lactose intolerance is less obvious among ice cream eaters. Consumers seem to be able to better handle lactose in ice cream. Perhaps the response is partly "psychological."

Interviewer: How did this project arise?
 Mr. Rotunno: The product was first talked about four years ago. I mean as an *Easy 2%*-type product. Marketing saw the need for a lactose-reduced offering. By that time, R&D had developed a good understanding of the technology. R&D had evaluated many enzyme systems, and

Exhibit IV.5. Pricing

Size	Recommended Selling Price (\$, as of 1991)	
	Easy 2%	Regular Milk
1 Quart	N/A	0.89-0.99
½ Gallon	1.89	1.59
1 Gallon	2.99	2.59-2.79

had uncovered a candidate which yielded a product with good flavor. Our R&D department was at the forefront of technology. We were not very progressive in the marketing side. We, in marketing, don't put a lot of money into pioneering new products. We regard ourselves as commodity-type marketers. But, R&D does invest strongly in pioneering new technologies that relate to our business interests. And the company does put considerable amounts of money into new processing technologies.

We now have seven Dean Foods brands and 16 regional brands, so we do have a number of specialty products. But, the number of branded products, we have, is not expected to change dramatically. Our "thing" is to produce quality products at a low cost. And we are "state-of-the-art" in processing. We feel that we are the best at what we do. We have purchased successful companies in expanding our business. And we have supplied capital. We are investing strongly in processing plants. Dr. George Muck has the responsibility of having everything coming out of our plants to be of the best quality.

Our products are not the cheapest. The emphasis is on quality. Our products tend to last seven days after the stated coded life. That speaks to the quality of our products. So, considering these aspects, I believe we are more R&D oriented than we are marketing oriented in how we approach our business.

We now have a lot of brand names all over the country. At the national level, we are number two in our industry.¹¹ We have about \$1.3 billion in dairy and ice cream sales, with a total sales volume of \$2.2 billion. Borden's is presently number one, nationally (in 1991), but there is some restructuring going on which may

change their position. Other competitors include H.P. Hood (in the Northeast), Crowley (in New York), and Kraft (in the dairy case with their cheese and ice cream products).

But coming back to *Easy 2%*, right now, we are not satisfied. It's a good item. We're working on raising the sales volume. We're getting a lot of publicity on it. *Easy 2%* fills a need in the marketplace that other companies won't fill. We're getting positive feedback from our customers.

In terms of our marketing tactics, we have been more aggressive for *Easy 2%* than we have been for other products. Considerably more money has been invested in its promotion. That's because the potential for volume is very high. The problem we face is an awareness problem, and if we have the resources to reach those consumers. Part of the problem is how to get people away from certain attitudes and to increase their willingness to try the product. Children may be the key. Their bodies adapt, given the opportunity. So children may trigger the need for the product, within the family. If children use the product, adults will follow. We wonder if we should put the product into quarts to facilitate its use.

So, there still is a tremendous potential for this product. The question is: How do we tap into potential uses? Do we continue with our present spending level (of \$250,000 per year) for advertising and promotion. That level is about two percent of our total sales in the specific market area, and is one percent of total sales of all our markets.

We have a "tentativeness" about *Easy 2%*, in terms of how, and to what extent, should we promote it, considering our other products. When we first came out with it, we were very aggressive. It's been out one and one-half years. We've made money, but have not achieved the budgeted sales level. We have been moderately successful. But our company wants quick results. We see the potential and expect that awareness will increase. Our competitors in the pharmaceutical sector are spending substantial sums of money for the ultra high temperature-treated products.

Interviewer: How important is this product to the company? On a scale of (1) Nil—to (10) Extremely Important, what rating would you give it? What rating does it have in terms of importance to the marketing division?

Mr. Rotunno: The product is “somewhat” important to the company’s overall image so I would give it a “3” in general importance. Its total volume is not high; so if we stopped selling it today, it wouldn’t hurt us. *Easy 2%* answers a need. It helps protect our “flanks,” our flagship products. It is a “flanker item.”

In terms of the marketing department, I’d give it a “6” or “7.” That’s because we have had more publicity and more consumer interest in *Easy 2%* than in any other product we have produced. So, in a sense, the product has more potential for producing favorable publicity than it has as a profit generator.

Interviewer: Specifically, what questions are you grappling with at the present time?

Mr. Rotunno: First of all, we are pondering what marketing strategy should we have for this product. Our basic decision, initially, has been to align ourselves away from “medicinal products.” We didn’t want *Easy 2%* to be identified as a medical solution. Our approach was an attempt to be more creative, rather than orienting the product as a problem solving entity. We now wonder if we should have been more “hard-hitting” in our strategies.

The second question relates to the first one. We are wondering how to best position the product in the store. Should the product have been closer to other “lactates?” But, we feel, in that regard, that the product doesn’t fit next to the “lactates.” If it was positioned that way, people would assume that it’s somewhat “medicinal.”

Our new fiscal year began June 1. The budget for *Easy 2%* was adjusted downward. That adjustment hasn’t adversely affected sales. Sales for *Easy 2%* are increasing, but very gradually.

Postscript by George Muck, Vice President of Research and Development

Dr. Muck: The problem is how do we tell the consumer who actually is lactose-intolerant that *Easy 2%* is good for

them and would be easily digested? When making these types of comments and claims, we do not want to infer that milk in general is bad. In addition the FDA allows only certain health messages to be used on food labels. They (the FDA) only allow health messages in six cases: calcium and osteoporosis, dietary fiber and cardiovascular disease, lipids and cancer, lipids and cardiovascular disease, sodium and hypertension, and dietary fiber and cancer. Furthermore, in those cases, the health messages must be truthful and not misleading, and they must be limited to the relationship between the ingestion of a dietary component and the reduction of risk presented by a particular chronic disease. The message must also be consistent with generally recognized medical and nutritional principles for a sound, total dietary pattern, supported by both a scientific basis and a consumer health message summary published by FDA and written so the label statement contains a cross-reference to the consumer health message summary. The message must also be consistent with FDA's nutritional labeling regulations.

Lactose-intolerance is not included in the health messages. However, I still think the claim that the product has had the lactose reduced, and would be safe for people who are lactose intolerant, would be appropriate. Numerous people do not even know they have this problem. This lack of awareness makes our task much more difficult. That is our problem. How can this message be conveyed better to people suffering lactose intolerance?

APPENDIX: INDUSTRY INFORMATION

The U.S. milk industry has grown from the arrival of a few cows to Jamestown in 1611 to become one of the most reliable, efficient and sophisticated delivery systems in the world (*Milk Industry Foundation*, 1991).¹² Along the way, many innovations in processing techniques were achieved. The total U.S. market for dairy products, in terms of retail value, was estimated at \$30.7 billion in 1990.¹² As with other consumer products, there is strong competition for shelf space in supermarkets and other retail outlets. Among all of the retailers' products, dairy products and especially milk products are among the retailers most profitable products. Milk itself is an important

generator of profit dollars. Data from the Milk Industry Foundation (1991), citing Maxwell,¹³ indicate that, while milk continues to be one of the highest volume beverages consumed, its level of consumption, *per capita*, in the United States has been diminishing slightly in recent years (1970-1990), while per capita consumption of soft drinks has been increasing substantially. In 1990, per capita soft drink consumption more than doubled the level of per capita milk consumption. On the other hand, according to Jeff Reiter¹⁴ of *Dairy Foods* magazine, the dollar value of fluid milk shipments had increased from \$19.0 billion in 1982 to an estimated level of \$25.0 billion in 1991.

CASE NOTES

1. *Easy 2%* is a trademark of Dean Foods Company.
2. "Dean Foods Introduces an Easy-to-Digest Milk" (*Easy 2%*), press release, Chicago, May 2, 1990.
3. *Dean Foods Company Annual Report to Shareholders for Fiscal Year Ended May 26, 1991*.
4. From *Dean Foods Company 1990 Annual Report*. Note that product names that are trademarked, or assumed to be trademarked, are generally indicated in italics. For example, *Easy 2%* is a trademarked milk product of the Dean Foods Company.
5. See the article by Ellen Dexheimer, Jeff Reiter, Jack Mans, and Mike Pehanich, "1991 Processor of the Year," *Dairy Foods*, Vol. 92, No. 12, pp. 36-53 (November 1991).
- The acquisition of the *Birds Eye* frozen vegetable business (and the *Birds Eye* trademark) from Kraft General Foods was reported in a news release by Dean Foods Company on December 27, 1993. Record sales and earnings, reported for the quarter ended August 28, 1994, were in part attributed to the contribution of the *Birds Eye* acquisition.
6. See George Lazarus, "Dean Foods takes a big dip into low-lactose milk line," *Chicago Tribune*, Section 3, p. 4 (September 17, 1991).
7. See Nancy Ryan, "For Dean Foods, U.S. is where the heart is: Firm resists joining others in the industry in rush to expand overseas," *Chicago Tribune*, Section 7, p. 5 (February 7, 1992).
8. Article by Ellen Dexheimer, Alan Levitt, Mike Pehanich, Jeff Reiter, and Paul Rogers, "Movers & Shakers," *Dairy Foods*, 5th Annual Edition, pp. 6, 18, 44, reprinted from the April 1991 issue.
9. *Dean Foods Company Third Quarter Report for the Quarter Ended February 23, 1992*.
10. With respect to lactose intolerance (Exhibit 4), it was estimated that almost 100 percent of the Asians, who were lactose intolerant, had fairly violent reactions (cramps, gas, diarrhea, nausea, etc.).
11. Some industry information may be found in the Appendix above.
12. Historical information and data were obtained from the *Milk Industry Foundation*, "1991 Milk Facts," International Dairy Foods Association, Washington, D.C.
13. The data given by the Milk Industry Foundation for beverage consumption cited John C. Maxwell, *Beverage Industry*, February 1991, Copyright 1991, as the source.
14. Communication from Jeff Reiter, senior editor, *Dairy Foods* (now owned by Cahners Publishing Company, Chicago, IL), "Structure of the Dairy Processing Industry," received December 18, 1991.

Chapter V

R&D and the Product Development Process

We set a very aggressive schedule, then turn people loose and let them do the job.

—Carl S. Carter, Lockheed Corporation

Orientation to traditional postures can impede progress on projects.

—Herbert Blades, Du Pont Company

Long term, an R&D effort becomes ineffective when it deals solely with incremental improvements.

—Dhani Watanapongse, Inland Steel Company

ASPECTS OF PRODUCT DEVELOPMENT

Technological innovation, research and development (R&D), and product and process development represent activities that overlap. Technological innovation, the global process, includes all activities and stages, ranging from the initial planning and concept development through commercialization and growth. R&D is the vehicle through which technological innovation is executed within organizations. Outputs from R&D are new or improved products and processes that, hopefully, are successfully utilized in completing the innovation process. Products and processes are intimately intertwined. New processes are the methods by which new and improved products are manufactured. Manufacturing processes are necessary ingredients for completing a new product innovation or for increasing profitability of an existing product.

Products are physical embodiments which perform functions that are valued by the users. But, they are much more. They represent complex systems of use which ideally lead to a long-term psychological connection between providers and users (Wasson, 1971; Amabile, 1983). In the process,

products become “brands.” Products arise through creativity and reflect achievement of innovation by individuals or organizations. They have aesthetic qualities as well as utility—utility to the user and very importantly, utility to the parenting organization by providing returns which sustain further growth. Products derive from the process of product development. Organizations become identified by the products they develop.

The products can range in novelty from simple clones (new to the organization but not new to the marketplace) to radically new offerings (representing first-to-market products with unique properties). Since products that are unique when introduced tend to achieve higher periods of longevity, that category is most interesting. Longevity may also be gained when users incur switching costs if they move to other offerings. The most desirable situation occurs when a specific product is unique, proprietary, identified as a brand, and is part of a use program which favors, even requires, the use of an organization's other products and services. Within every product, services are rendered to some extent. Many organizations will intimately link extensive service “packages” with products to enhance and sustain relationships with their customers.

As products mature and age, they will frequently take on the attributes of commodities. They may have evolved from highly profitable new offerings to become revenue-generators. But with declining profits from competition, mature products may become commodity items on the way to decline. Since commodities are highly vulnerable to price erosion, having a product portfolio that contains a large proportion of commodity items threatens long-term viability. Balancing of product portfolios represents an effective strategy. At any given time in an organization, there should be mixes of products newly under development, products being introduced into user domains, rapidly growing new products in dynamic markets, along with some maturing or declining products.

Product Development Professionals

The topic of product development is best introduced by considering what the ideal, modern product development specialist is all about. In the realm of technological innovation, such individuals will most commonly be technically trained and will have mastered a particular discipline. As creative individuals, they will also be broad in their perspectives and interests resulting from wide-ranging levels of curiosity. The following qualities or traits have been observed among such individuals:

- A meticulousness for detail,
- An ability to make quantum leaps,
- An alacrity for risk,
- A sense of the heroic,

- An avidity for proceeding step-by-step,
- A desire for maximum data,
- An impatience for getting the job done,
- An emphasis on perfection,
- An interest in cooperation, and
- A sense of individuality.

Who are these cautious cavaliers, these meticulous matadors? Depending on their energies, abilities, and interests, they play various roles and may be located in a variety of positions around organizations. In the industrial setting, they most commonly reside within R&D. They might be inventor-types positioned in small groups or be members of larger groups in a mature R&D division. They also may be members of marketing or manufacturing. They may be researchers in various university environments or in government-run institutions. Or, perhaps at the moment, they are lone individuals, budding entrepreneurs, on the way to starting successful new enterprises. They can operate at various levels, ranging from a supporting technician up to the level of a CEO or chairman, depending on the size of the organization and the propensities of the individuals. If managerial, the individuals will usually be found in line positions, typically responsible for some aspect of innovation. If not managerial, the individuals will frequently report to a key manager who also possesses the characteristics of a product development specialist. Depending on their predilection for managerial roles, which is assumed to be common, such individuals will normally be upwardly mobile in organizations. And, very frequently, higher level managers, for example, directors of R&D or vice presidents of technology, will have attained their ranks because of significant product innovations achieved earlier in their careers.

It is less likely that such individuals will be found in service-oriented or supporting roles—although such may be the case for a limited period earlier in their careers. Therefore, it is less likely to find such individuals in such areas as marketing services, analytical support, legal services, etc. Yet, staff functions contribute important elements to the process.

The reason for a predisposition to line-orientation among product development specialists derives from a need for empowerment. Such individuals, by dint of their personalities and basic needs, find it increasingly important to be able to control situations, at least sufficiently to achieve the objectives. It is not enough to simply create ideas, although participation in idea generation activities is quite strong. Satisfaction, rewards, and continuing motivation generally spring from successfully completing the product development process, that is, achieving commercialization or launching the new development into user domains. To be successful,

products must be substantially viable for a sufficient period of time to enhance the organization's stature or increase the firm's sales and profitability. In other words, the process of innovation must be completed.

To achieve these ends, the product development specialist must work tenaciously, with high levels of motivation. Inevitably, dead ends or failures will arise and will trigger frustration and even dismay. But such failures cannot cause distress for very long since other avenues, other opportunities, must be pursued.

Technical specialists interact with sales, marketing, operations, financial, and top management personnel, and literally have to "sell" their products and ideas in order to gain acceptance and achieve coordinated efforts. Problems may arise. Although modern management approaches strive to emphasize the values of cross-functional teamwork and boundarylessness in organizations, provincial attitudes may persist and impede goal attainment. One organizational subsystem may regard another purely as a service function, that is, as one which should become subordinated to the other. Throughout the organization, managers and executives "compete" for promotions to higher levels or for a greater share of limited resources. Often, a person achieving the highest level, that of a CEO, will have done so by having earlier led major new products programs. Such dynamics spur the process of innovation. Inevitably, as with most human endeavors, the process of product development takes on dynamics which are sociopolitical in nature. These aspects must be reckoned with by the individuals and leaders involved.

Because of a potentially high product failure rate, frequently near 40 percent or higher (Crawford, 1991, p. 7; Gruenwald, 1992, p. 13), and because of environmental constraints and pitfalls, individuals who can successfully produce new products are highly valued by organizations. These individuals must possess technical ability, marketing skill, and courage and caution. They must be able to balance these aspects appropriately.

Activities and Requirements in Product Development

In this work, product development is considered to encompass the universe of activities aimed at promoting, directing, determining, and satisfying the needs of consumers or users in a profitable fashion by designing and supplying products. The very nature of the product development activity (and innovation) requires continuity. If the position of the organization in its competitive environment is to expand, or even be sustained, new products must continue to be introduced and have high rates of success.

In a generalized model of product development, all pertinent activities are included, such as, planning, idea generation, feasibility studies,

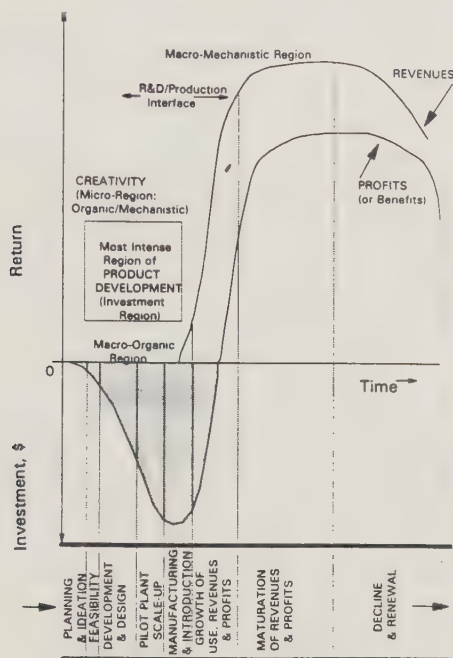


Figure V.1. Pipeline Model of Innovation Keyed to Product Life Cycle

marketing research, prototype development, process development, engineering and manufacturing scale-up, user education, commercial introduction, and brand maintenance. Figure V.1 illustrates the progression of stages in terms of the product life cycle and pipeline models of innovation (Booz, Allen, & Hamilton, 1968, Twiss, 1980; Ginn & Rubenstein, 1986; Ginn, 1986). The stages of development can and should be operated concurrently. Yet, we are also progressing through a process, a process in which certain milestones need to be achieved at various points in order for passage to the next stage to make complete sense. A failure in any one activity of the product development process may result in overall failure so each phase becomes important. Brand maintenance activities become important in order to sustain a product after it is introduced into the marketplace. Such activities include maintaining quality and quantity of raw materials, managing product liability issues, etc.

The activities of product development are directed toward achieving implementation. With interactions required among all segments of an organization, all functions contribute to some degree. The adoption or creation of new technologies plays a central role so R&D, engineering, and operations are key players, along with marketing, sales, finance, human resources, and the top management echelons. The number of embedded activities becomes very large, if one considers typical requirements (Figure V.2).

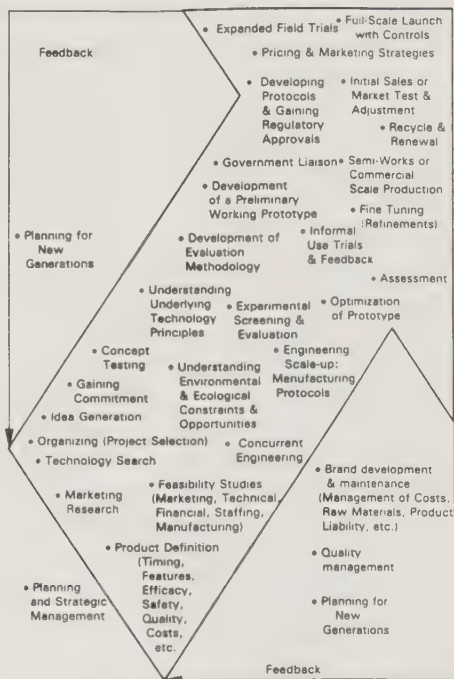


Figure V.2. Activities in the Process of Product Development

The requirement of profitability or organizational enhancement is also included in our definition of product development. A successful new product represents a new asset for the organization. A product may represent an ingenious invention, but remain unprofitable because of various factors such as poor economics in design or manufacture, quality problems, inadequate marketing, or sales support, etc. This would constitute a product failure.

The success of any product development effort depends on whether or not a product meets certain conditions, and particularly the following:

- *Relevancy/efficacy condition:* A product must perform. It has to stimulate, direct, and/or meet the needs of the consumer.
- *Safety and quality:* A product must embody safety and quality in all aspects of development, manufacture, distribution, use, and residual impact on the environment.
- *Profitability:* A product must yield an adequate financial return or contribute significantly to the equity condition or core capabilities of the organization.
- *Longevity or sustainability:* A product should have an impact for a sustained period of time—sufficient to be a significant and

recognized factor in the marketplace or within the stakeholder community of the organization.

The above criteria are stated in order to make an important distinction between product development and R&D. Product development is a generic process involving the cooperation of various functions to attain the desired end results. R&D, on the other hand, refers to a functional element which is a primary means for achieving the end result, namely product development. While this simplistic distinction may seem obvious, it is important to note that R&D organizations have become obsolescent, have even been disbanded, because the organizations themselves became the end, rather than the means for product development.

As long as a firm insists on and has a steady flow of meaningful accomplishments from its R&D, as measured by returns on investment, or attaining platforms for future returns, then the R&D department will endure. If the pay-out is less than adequate, even though disguised in sophisticated trappings, R&D very likely will be cut because it is more vulnerable than sales or manufacturing during tight economic situations. R&D managers have to provide advocacy as business managers. In this respect, R&D professionals should continuously play the role of devil's advocates in looking at their own performance. Emphasis has to be placed on the number and quality of successful new products developed, in relation to levels of investment.

There is also the "flip-side" of the argument, that is, the inherent dangers of focusing too strongly on short-term, incremental research. Organizations that solely respond to the wishes of their customers, no matter how important and powerful they might be, run the risk of becoming buried in creeping incrementalism. As a result, they may become obsolescent technologically and that could lead to an eventual demise. Organizational entropy or inertia may exist which deepens a given response, once it is adopted. If an organization opts for a strongly centralized R&D effort, with a purely technology push orientation, resources tend to be funneled in support of that design. The investment in that design tends to be increased in response to continuing efforts to achieve critical masses in newly emerging areas. Similarly, in a decentralized orientation, an expanding customer base will generally signal new opportunities which would require additional resources, manpower, and capital, and new divisions to be able to pursue them effectively. So, as a result, it is anticipated that centralized organizations would tend to become more centralized, and decentralized organizations would tend to become more decentralized as time progresses. At some point, in each case, difficulties would arise that would signal the need for a major paradigm shift. To avoid such dislocations, it would seem far better for the organization to build in flexible response capabilities,

adopting appropriate patterns of organizational designs consistent with evolving environmental changes.

In summary to this point, product development is considered to be an end to the means of R&D. As such, we have the superposition of a goal-oriented activity within a functional subsystem with impacts on cross-cultural relations. Viable R&D efforts must continuously produce successful new products in order to survive and expand along with the organization as a whole.

MODELS FOR THE PROCESS OF PRODUCT DEVELOPMENT

The models for product development or innovation in the literature are many and varied, and they continue to evolve. Figure V.3 reviews some important geometries that have evolved over time. Product life cycle models continue to be utilized extensively as descriptive tools, as aids in planning, and as means for understanding the leveraging that results from product innovations and from portfolio management. For organizations deriving income from product marketing, the cumulative effect of multiple life cycles

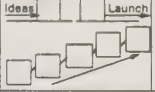
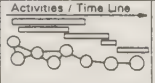
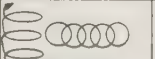
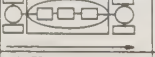
MODEL TYPE	SCHEMATIC REPRESENTATIONS	FEATURES OR BENEFITS	SUGGESTED READINGS
Life Cycles		Describes revenue, investment & profit flows or produced units in relation to stages and time. Useful in planning; but is retrospective and not predictive in nature.	Booz, Allen & Hamilton (1968); Wesson (1971); Twiss (1980); Willyard & McClees (1987); Clark & Wheelwright (1993, p.100); Foster (1986).
Staged, Modular Flow or Step-wise Flow Diagrams		Describes stages traversed, moving linearly or step-wise from ideas through launch (conversion processes).	Sommers (1982); Soren (1984); Ginn (1986); Crawford (1991, pp. 25-35); Davenport (1993, pp. 132, 222).
Gantt/PERT Diagrams, Critical Path Networks		Can organize a large number of activities, including concurrent ones. Useful in planning and control.	Skinner (1972, p. 122); Bellas (1973); Dundas & Krentler (1982).
Loops & Chains		Reflects stages and linkages among elements.	Sirkin & Stalk (1990, p.27); Martin (1984, p. 20).
Systems Analysis Models		Can describe inputs & outputs, including integrating elements.	Nadler & Tushman (1988, p. 159).
Integrating Models		Models integrate and couple various elements including the environment.	Twiss (1980, p.18); Rothwell (1992, p. 222).
Concurrent Cross-Cultural Systems		Emphasis is placed on concurrent elements, e.g., as in concurrent engineering.	Rothwell (1992, p. 237); O'Neal (1993); Clark & Wheelwright (1993, p.472).
Funnel Designs		Screening from many to few or one.	Clark & Wheelwright (1992, p. 301).

Figure V.3. Models or Geometries for Product Innovation

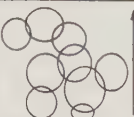
MODEL TYPE	SCHEMATIC REPRESENTATIONS	FEATURES OR BENEFITS	SUGGESTED READINGS
Linked Circular Models		Activities are linked as inputs from team member groups. Open structure readily permits additions of new team members.	Mendez & Pearson (1994, p.9).
Circular or Elliptical Team Elements within a Larger Team Circle		Teams providing various support elements are placed in regions as members of a larger team which has a specific identity & charter.	Millison, Raj, & Wilemon (1992); Byrne, in <i>Business Week</i> (1993, p. 81); Deavenport (1994).
Radiating Concentric Circles		Milestones moving out from or in towards the center. Permits linear and circular elements. Easily expandible.	R. Skinner (1972, p. 43); Clark & Wheelwright (1993, p. 183).
Circles and Arcs		Areas within arcs within circles designated as activity areas.	Teece (1988, p. 632); Mintzberg (1993, p.364)
Circles and Satellites		Network of circular patterns with satellite groups or nodes of activity.	Kolodny (1990, p.189); Henke, et al. (1993, p.221); Deavenport, (1994, p. 37).
Spiral Patterns		Used effectively in describing patterns of change.	Mintzberg & Westley (1992, p. 41).

Figure V.3. (Continued) Models or Geometries for Product Innovation

determines the nature of the organization's revenue flow. The revenue flow determines the organization's ability to invest in developments for the future.

Product development is generally regarded as progressing through stages, which can be superimposed on life cycles or expressed separately in modular flow diagrams. Each module reflects an important milestone that has been achieved in moving through the process. Activities are commonly expressed on a time line, utilizing Gant charts and network diagrams to reflect and control progress. Loops and chains can be used in acknowledging platforms and linkages that exist as one moves from one stage to another. Since product development is a powerful value-added process, systems analysis models, with elements of inputs, transformations, and outputs, are frequently encountered. By combining and integrating various features, hybrid models have provided more elaborate landscapes of the process. Specific features have also been added, for example, to reflect benefits of concurrent engineering and the fundamental nature of screening that is involved.

Although the geometry is far from new, circular models have been applied more recently with greater and greater frequency. Circular models supply several benefits: They are compact and minimize the distance between contributing elements. They are ideally suited for emphasizing team

structure. They are versatile. And they avoid or minimize the perception of hierarchical barriers within the organization. Several versions have evolved, including linked circles, circles within circles, concentric flows, satellite designs, and spiral patterns.

Saren (1984, p. 24) concluded, following a systematic review, that "a general model is (still) required which accurately segments and describes what occurs during the innovation process." There has been considerable progress as is evident in Figure 3. Efforts continue in this regard (Byrne, 1993, p. 81). Yet, the conclusion of Saren still seems to hold to some extent. There continues to be a need for a simple model which is general in perspective, yet is also descriptive in detail. That has been attempted and has led to the "SpaceEnd Model" which is described in the following section.

The SpaceEnd Model

The term "SpaceEnd" is used as the name since the model has elements of a space vehicle (the product) that is moving out from a planet (the organization and its contributing components) to reach outer space (the user or consumer environment). The model also draws upon the analogy of an atomic system with its nucleus and its electron shells, including the notion that certain quanta of energy must be introduced in moving from one level (or stage) to the next. In this model, the organization engaged in product development consists of the nucleus or a planetary core surrounded by concentric rings moving out from the center to a surrounding region which is called "consumer space" (Figure 4). The products move into the realm of users or consumers through the integrated efforts of contributing elements, the organization's individuals, functions and teams. According to the model, each product that evolves from the process of product development is described as having a mission.¹ The performance of the product mission is traced by the course it follows moving into consumer space. By this analogy, we can avoid thinking of products as having a finite life and, therefore, an inevitable demise. The success and longevity of a product in its "marketplace" are viewed in relation to fulfillment of the product's mission. Accordingly, a product can continue to be viable indefinitely and can be readjusted periodically to take on new characteristics and new missions. Or the mission can indeed abort and the product can move toward extinction.

Activity Stages and Functional Participation in SpaceEnd

In Figure V.4, the immediate realm of the firm is considered to be the nucleus and the concentric shells, the stages, through which products progress. Five diffuse boundaries are noted in the figure; but depending on

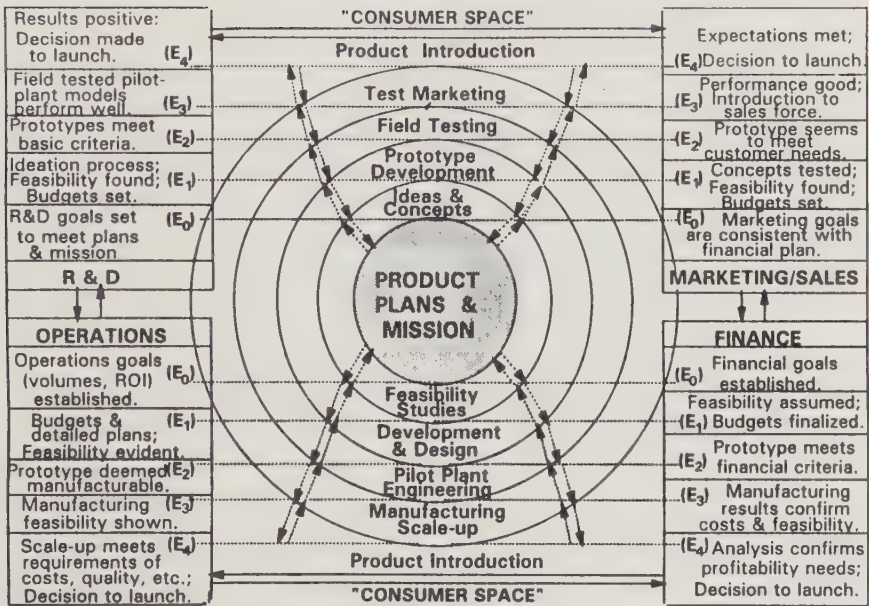


Figure V.4. A SpaceEnd Model for Product Innovation

the firm's specific requirements, more or fewer boundaries can be utilized. Beyond the region of the outer shell is the region of the customer space where end-users are located. Directional flow during the product development process is considered to be primarily from the center outward reaching to the end-users and/or inward toward the center considering flows of revenues, information, and ideas. Although product movements are ideally outward, products can move back and forth from one stage to another, depending on the success attained in meeting relevant criteria.

Permeating the entire matrix is the environment of the firm. A product is influenced by the environment before it leaves the firm and after it enters consumer space. Various environmental impacts involve all elements that are generic to the term "safety," including concerns of pollution and addressing matters relating to governmental regulations, social welfare, consumerism, and so on.

Components of the SpaceEnd model of product development are as follows:

- An organizational nucleus, where corporate plans and the charter evolve (Stage-0). The nucleus includes the organizational

infrastructure and the participation of all key individuals and groups in the organization.

- Ideation and feasibility studies (Stage 1).
- A laboratory formulation stage, where the design, formulation, and packaging specialists creatively transform raw materials into a finished product, demonstrating feasibility and performance (Stage 2).
- A stage of pilot-plant development where the laboratory work-up is translated into a small-scale manufacturing process—simulating actual plant conditions. Concurrently, the product is put out to selected user groups for field testing (Stage 3).
- A stage of manufacturing scale-up and test marketing aimed at demonstrating the product's commercial feasibility and acceptance by the consumer (Stage 4).
- A product introduction stage (Stage 5) in which the product is launched into the marketplace or into the user domain on a larger scale where growth patterns evolve depending on many factors (Skinner, 1972).

The boundaries between activity layers represent decision points. If the decision is favorable, the product passes outward to the next layer. Specifically, passage to Stage 2 from Stage 1 requires that a favorable decision has been made to develop a laboratory prototype. The product concept has been shown to be innovative and feasible, with significant potential for successful application in the user domain.

Passage from Stage 2 to Stage 3 requires that the developed laboratory prototype be considered to possess the qualities desired for field testing under actual use conditions.

Stage 4 is attained when a pilot-plant preparation shows manufacturing feasibility and when the resulting product performs well in the field testing.

Passage from Stage 4 to launch requires that all criteria are met, including those relating to design, performance results, and manufacturing experience, to justify introducing the product on a larger scale.

Thus, each boundary indicates that a particular milestone has been reached. By analogy with atomic theory, one may envision that a certain quantum of energy is required to pass from one level to the next. This concept of energy quanta is appropriate since it suggests that cooperative energy must be introduced in order to move the project or product closer to the consumer. Indeed, using the model of quantum mechanics, the energy required may be considered as a summation of energy contributions from various functional groups within the organization, allowing for inputs from the external environment. Interface problems would be expected to increase the energy required to bridge a particular interface. The contribution of each functional element is key to the viable

progression of a product development project. Failure of any one of the participating groups may disrupt the progression—or may require that another functional element be introduced to fill a gap.

Another interesting criterion which may be applied to the model is the concept of *escape velocity*. In order for a space vehicle to leave a given body it must overcome the attractive forces of that body. In the case of product development, such forces may arise from inertia, timidity, inadequate work-up, confusion of data, or from interface problems, just to mention a few possibilities. It is therefore important that there be a consensus of participating groups, a consensus sufficient to overcome these forces and provide the necessary impetus for a successful new product introduction.

In atomic theory, the energy required to pass through each succeeding layer moving outward from the nucleus is less and less. This occurs because the electron in the atom is overcoming the highly attractive opposite charge of the nucleus. The analogy with industrial product development and the conceptual model seems to hold as well in this regard. Thus, it seems to take the most energy and effort to come up with very good ideas, ideas which are innovative and high in potential for success. With good feasible ideas, virtually any step in the process can be traversed. Very good ideas rapidly gain support and commitment from various power centers in the organization. When there is commitment, implementation can become something like a “self-fulfilling prophesy.” Without commitment, support becomes limited and progress inevitably stalls.

Organizational structures are important, but product development can be successful no matter what structure is employed, as long as the subsystems contribute all that is needed. Structure also implies hierarchical assumptions which we strive to minimize. Structures may be invoked which avoid hierarchy, but these may lack directionality of focus. We want to minimize hierarchy but we want to recognize the need for directional flow. That is accomplished through the SpaceEnd model. Commitment and cooperation by the various functions are crucial ingredients for successful product development. That is the essential “message” of the model.

Use of SpaceEnd Model to Monitor Properties

Various properties such as safety, environmental compatibility, quality, and efficacy and cost requirements can be described and monitored by the model as the progression proceeds closer to launch and the consumer (Figure V.5). Efficacy is determined throughout every level of the system, evolving from the viability of the new product idea through various layers of performance evaluation in order to confirm consistency of results. Safety testing proceeds concurrently, such that, as the product moves closer to the end-user, appropriate tests are performed and the required results are obtained. Such test results are needed to be sure that the product will be safe in use and

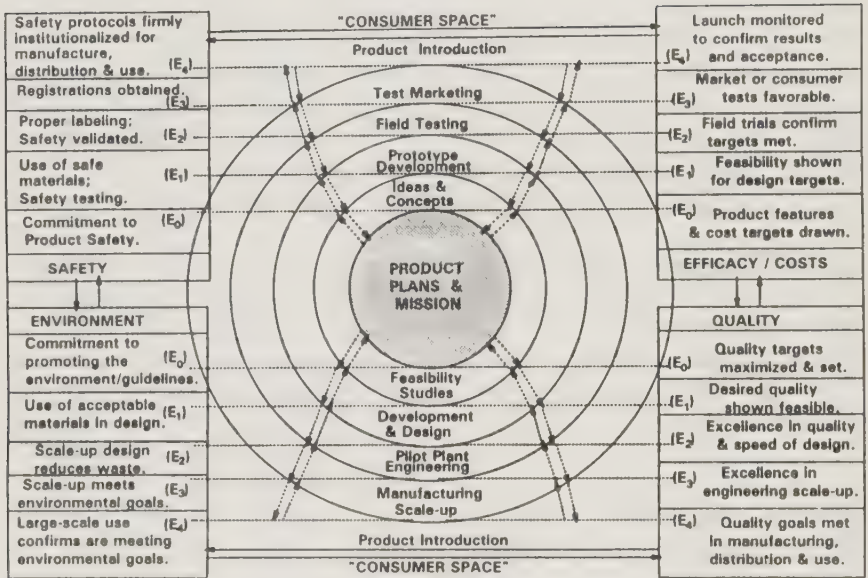


Figure V.5. Evolution of Product Features in the SpaceEnd Model

to ensure that appropriate cautionary statements are employed in labeling. Checkpoints are introduced to ensure that company plans are compatible with the environment, that conceived ideas meet energy and environmental requirements, that in-house laboratory and independent laboratories establish and verify safety and appropriate labeling, that corrections of product are made as necessary to ensure safety, and that the consumers verify that the product is safe and energy conserving in use.

While safety and efficacy are given as examples because of their importance, other parameters can introduced into the model depending on the need for focus.

Introduction to Consumer Space. Introduction of a product into the user environment is analogous to the launching of a space vehicle. The vehicle or product can move outward on various paths (Figure V.6). The curves may be described as instant failures or instant aborts (curve A), or completed cycle curves of the type where the curve has passed through introduction, growth, maturation, decline, and extinction (curve B). However, the more significant curves are growth curves which have longer durations (indicated as curve C and curve D).

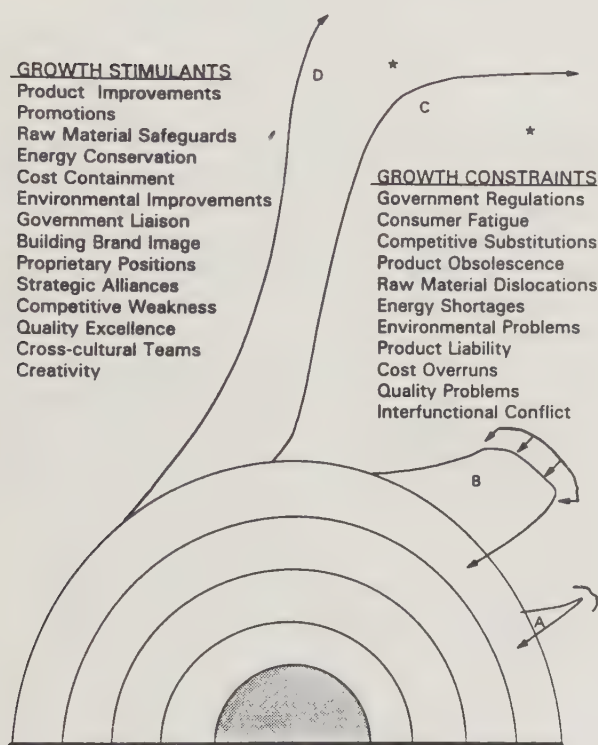


Figure V.6. Product Growth Issues in Brand or "Mission" Maintenance

As with the product life cycle concepts, the product missions may be shortened or even terminated by many occurrences just as a space mission may abort because of faulty engineering, human failure, collision with another body, and so on. With a product, the missions may be deterred or aborted by growth constraints such as: governmental regulation, consumer fatigue, competitive replacement, product obsolescence, energy or raw material shortages, etc. Elements fueling growth and continuation of the product mission are: promotions, product updates, raw material alternatives, energy conservation, good and proper quality control, among other factors. As the mission proceeds in a growth pattern, sales of the product also grow.

The existence of long-term growth curves, without the necessity of demise, suggests the fundamental difference between these curves and product life cycle curves. The concept avoids the difficulty of life cycle theory which regards a product's life as finite. According to SpaceEnd model, the mission (or product life) may range from short term to centuries—there may be a limit but there is no necessity of a limit.

PROJECT MANAGEMENT

At the “macro” level, the various new products that are to be developed, are typically viewed as evolving through *projects*. Project management encompasses many issues or elements, including those of strategic management, project acceleration, and leadership. Key subsystem elements of strategic management include: a mission, objectives, a situation analysis, strategies, tactics, budgets, controls, feedback, and reformulation. These elements need to be developed at four levels: the corporate level, the business level, the functional level (e.g., R&D), and the project level. All elements should be integrated so there is internal consistency throughout. For example, mission statements at corporate, business, R&D, and project levels should dovetail and should evolve from bottom-up as well as top-down analysis. All pertinent constituencies, including key creative professionals, should participate in the planning process. Reward systems should be tied to achievement of the plan. That will help to ensure commitment to project success. Excellent guidelines for project evaluation and selection are available from the writings of Twiss (1980) and Martin (1984). According to Twiss (1980, p. 92), it is important to identify the *criteria*, the relevant factors, that are to be used in assessing the various alternative possibilities. Such criteria are essential and fundamental in any decision-making process, if circular reasoning is to be avoided. The project leader and all pertinent constituencies should participate in analyzing and formalizing candidate projects in relation to those criteria. The criteria should be specific to the goals and philosophies of the particular organization involved as embodied in its strategic plan. Based on the recent writing of Rubenstein (Albala & Rubenstein, 1994), it would be important to assess the merit of possible alternatives against the organization’s technology strategy, that is, its core competencies and learning priorities.

Cross-Functional Product Development Teams and Compression of Development Times (Project Acceleration)

Many cogent arguments can be raised in support of the use of cross-functional teams and the benefits of project acceleration in product development. The areas of teams, concurrent engineering, and acceleration have been frequently linked with one another (Starr, 1992; Zahra & Ellor, 1993; Iansiti, 1993; Robertson, 1993; Karagozoglu & Brown, 1993; McDonough, 1993). The saving of significant amounts of time is a major benefit that is associated with use of cross-cultural teams (Hershock, Cowman, & Peters, 1994; Ancona & Caldwell, 1990). Use of cross-functional teams provides a useful mechanism for minimizing a sequential approach in product development, thus facilitating simultaneous or concurrent

actions. Cross-cultural linkages and integration of activities become especially important as the levels of sophistication increase for applied technical systems (Rothwell & Whiston, 1990). As the need for communications increases among functional subsystems, cross-cultural teams become increasingly important (Allen, 1986). "Breakthrough teams" were suggested by Stalk and Hout (1990, p. 220) as one of several cross-functional approaches recommended for increasing competitiveness based on time-based management.

The use of cross-functional teams and the "acceleration ethic" often comes into play when *imperatives for action* are introduced by top management. Such imperatives include announced increases in the number of new products to be introduced within tight time-frames, or arise when management issues dictums (superordinate goals) in order to break through difficult interface problems (Ginn & Rubenstein, 1986). So, in a sense, team formation is a common response to threatening or hostile situations, or to situations that involve extraordinarily attractive, but short-lived opportunities. Teams are commonly invoked to take advantage of "windows of opportunity." Wheelwright and Clark (1992, pp. 31, 33) and Clark and Wheelwright (1993) eloquently argue the need for speed, along with efficiency and quality, as "imperatives" for operating effectively in the competitive environment, and identify cross-functional teams as key mechanisms for achieving those imperatives. In the domain of high tech marketing, "product timing is critical" and managers must be able to make the hard-nosed decisions, based on objective analysis, to ensure being first-to-market (Flanagan, 1993, p. 29). Communications and integration of efforts between marketing and R&D are very important as facilitating mechanisms in project management (Moenaert et al., 1994). Cross-functional cooperation increases when informal communications channels are utilized effectively (Pinto & Pinto, 1990, p. 208).

As use of interfunctional teams and project acceleration techniques have increased, evidence has also emerged that such approaches are *not* universal panaceas. There are potential downsides which must be reckoned with and which moderate the generalizability of the acceleration approach (Millson, Raj, & Wilemon, 1992). When applied indiscriminately, "speed can produce poor decision making and ill-fated products" (Utterback et al., 1992, p. 36). Teams can also be "overused," according to Henke, Krachenberg, and Lyons (1993, p. 218), leading to conditions of "teamitis" and "meetingitis," or to "dissatisfaction with teams" from protracted delays or from results that become pedestrian. In a most extreme manifestation, a kind of "rat-pack" research may evolve in which teams scramble helter-skelter from one research project to another in order to meet short-term commitments. As a result, the attention required for building and renewing core competencies may become compromised.

	Potential Benefits	Potential Pitfalls
Cross-Functional Teams	► Cohesion and commitment	► Pedestrian solutions may prevail
	► Peer pressure	► Individuality may diminish lowering creativity
	► Cross-pollination of ideas	► Hidden agendas may persist
	► Reduction of interface problems	► Indecisiveness may slow progress
	► Facilitated scale-up and implementation	► Excessive reliance on teams
	► Quicker time to launch	
Project Acceleration	► Can become first-to-market	► Can result in a short-term mindset
	► Can exploit windows of opportunity	► May perpetuate incrementalism
	► Can enhance competitive position	► Diminished slack may reduce creativity
	► Can learn to be quick, yet also be careful and successful	► Diminished slack may invite errors and impart stress
	► May encourage strategic alliances	► May "exhaust" core technologies

Figure V.7. Benefits and Pitfalls of Cross-Functional Teams and Project Acceleration

Others have leveled even more fundamental criticisms. For example, von Braun (1991, p. 43) has written about an "acceleration trap" in which product life cycles become shorter and, ultimately, lead to lower revenues than might otherwise result. Stalk and Webber (1993, p. 93), along with communicating the benefits, also expressed concerns about possible pitfalls of "time-based competition," when it is not managed with a proper balancing of other avenues for achieving competitive advantage.

Some of the key benefits and pitfalls of teams and acceleration are summarized in Figure V.7. One implication from these concerns and caveats is that managers should focus on building more unique properties into developed products, establishing and maintaining proprietary positions, so that product life cycles yield revenues for longer periods of time. Of course, to do that can require more time and more creativity in the development process. The use of teams and an emphasis on acceleration in new product development should therefore be moderated by judgment, considering a variety of factors. In other words, a balance is needed:

- A balance that meets short-term and long-term requirements,
- A balance that involves rapid responses, but also measured responses,
- A balance that meets customer needs and yet creates new technologies,
- A balance that encourages simultaneity, yet achieves important milestones, and

- A balance that utilizes team involvements, yet encourages individuality.

Some Project Management Guidelines

The following guidelines are suggested for managing projects which are aimed at achieving significant technological innovations through the development of new products:

- Progress through innovation stages:
 - Idea generation
 - Preliminary assessment, concept testing
 - Project selection
 - Prototype development
 - Concurrent engineering
 - Physical evaluation
 - Consumer (User) testing
 - Market test (large scale use)
 - Full scale launch
- Identify and implement key project elements:
 - Pervasively define the project (for example, its scope, problem, and mission), committing to target dates.
 - Divide the work into subtasks, identifying possible approaches.
 - Prioritize approaches; pursue the most favorable ones.
 - Adapt suitable structures and unstructures, utilizing team approaches where appropriate and encouraging individuality.
 - Exercise controls: monitor, derive feedback, and recycle as necessary, employing:
 - frequent, informal monitoring of what is happening on projects (staying in touch)
 - working meetings (weekly, monthly, etc.)
 - management through accountability in relation to targets (monitoring variances), peer reviews and management reviews,
 - readjust as necessary.
- Exercise appropriate motivation and leadership skills, show willingness to lead, by:
 - Gaining corporate commitment, addressing relationships of project strategies to organizational structure and culture,
 - Employing appropriate motivational and leadership contingencies as referenced in Chapter I.

Figure V.8 provides a systems analysis model of leadership that encompasses many of the above elements and serves as a framework for leadership at the project level. Formal authority is included as one of the inputs, but the overriding theme in the model is that leadership in project

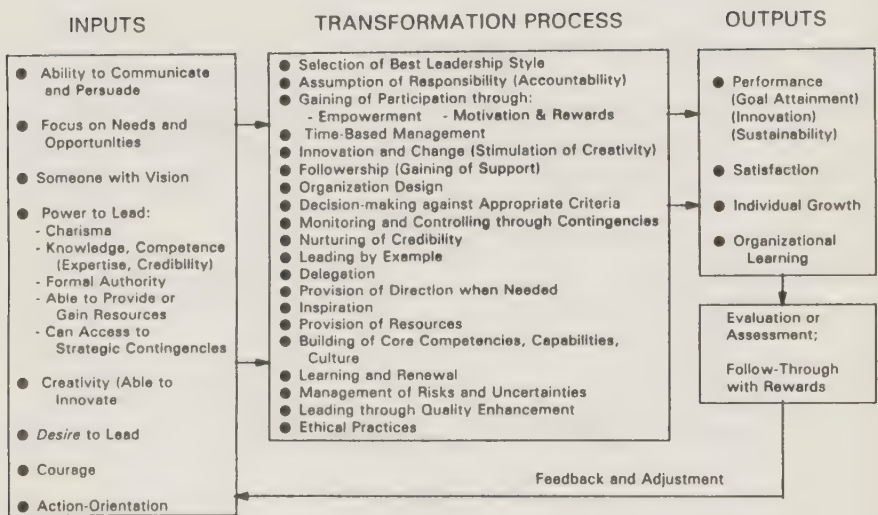


Figure V.8. A Systems Analysis Model for Project Leadership

management derives more from informal sources of power, that is, from strategic contingencies (Hickson et al., 1971) and from performance. In project management, project leaders frequently will be more junior than the various managers of functional divisions in the organization. The ability of project managers to be successful will depend on their ability to gain power and influence through informal mechanisms. Credibility, derived from past performance and from sustained excellence, is a very important factor in determining the level of influence that is obtained. The project manager must be patient and willing to go for the long haul. He or she must be able to build a solid reputation of success over a substantial period of time so that credibility is maintained. Although the toleration of failure is considered to be an important attribute for innovating organizations, a history of failures does not promote the credibility of a project leader. So, performance and effectiveness become especially important; and that derives from building a portfolio of accomplishments. As a result of these aspects, the project leadership role becomes an ideal mechanism for building general management skills. Those skills encompass competency, dedication, and persistence—qualities that already should exist among creative professionals.

Perspectives on Project Management and Creative Product Development

Interview with Herbert Blades, Consultant, Pioneering Research, Experimental Station, Du Pont Company

Dr. Blades: I believe that technical creativity is helped greatly by having a "sympathetic audience" and a *forum where there is lively debate*. Key people must be truly willing to hear what you have to say (to challenge and to be challenged). I have observed research reviews in which individuals described their research to managers and to peers without having adequate debate. What can happen is that individuals in the audience become reluctant to ask questions because they feel they might embarrass the presenter. When that happens, the system is not working. I believe that managers may not be aware of this problem. So, it is important for researchers to seek good forums, for example, at ACS (American Chemical Society) meetings where stimulating debate can be experienced.

A second ingredient which is helpful is to have *good mechanical facilities*. This is not as important as the first, but it can have an important bearing on the quality and time required for the research. In my career, I wanted to use equipment which was not available up to that time because we were pioneering new areas. The equipment was needed to make new kinds of measurements. On occasion, I would encounter bureaucratic obstruction. This resulted from budgetary constraints and the need for lengthy justification. When things bogged down, I designed a piece of equipment and built it myself. It took three years in one case. That's too long.

Orientation to *traditional postures can impede* progress on projects. For example, there was one particular episode which illustrates this point. A particular product was marvelously successful in its properties and performance. Everything was in place to complete and implement the concept. Yet this development also took three years to reach a point where it was able to be turned over to commercial development. Why? Because of *ingrained habits*. The technology and evaluation involved spinning of fibers. Tradition required that a technician had to perform those

operations for you. Because of backlogs and scheduling, a bottleneck was created. Managers felt that specialists should do certain operations such as filtering, sample preparation, etc. But I have found that impedes progress. In a sense, technology is being compartmentalized by tradition. When “professionals” do these operations, the work goes much faster.

Interviewer: But, as a counter argument to that, I have heard in some quarters that progress is slowed when professionals have to do too much mundane work—work which could be done by technicians, thereby freeing research professionals for more sophisticated activities. What about that argument?

Dr. Blades: In answer to that, it is important to recognize that professionals can become too isolated from the technology and not benefit from immersing in the routine operations. Such hands-on activity brings forth insights which might not be seen otherwise.

The problem also relates to a lack of flexibility by management. There is a strong bias on the part of managers to use supporting services. They tend to do this because that's the way the world is supposed to operate. The mind-set can be a serious barrier to progress.

Another impediment of a similar nature occurs in the “world of ideas.” For example, a traditional model for explaining how something works can hold sway and be difficult to challenge. When that occurs, new approaches can be blocked.

So, I have become skeptical of such traditional approaches. We have always had technicians and helpers which represented a substantial part of the R&D budget. I have often wondered if we would have been further along if we had allocated some of those dollars for hiring more technical professionals. I believe we would have been better off for the reasons stated earlier.

Considering impediments versus facilitators, I believe that responses depend strongly on the individual involved. Some individuals are completely suppressed by barriers. Others rise to the occasion and overcome barriers. I know of no general theme in this matter.

Interviewer: Can you tell me about projects which illustrate these aspects—projects with which you have been associated.

Dr. Blades: First, a negative one: We had derived a new process that looked quite interesting. I was the inventor. We

wondered about the next scale-up. There were several discussions. After considerable thought, I decided that there were too many unresolved questions in the procedure to warrant going to the next higher stage. I wrote a letter to my supervisor detailing my views on why we should defer the scale-up. He came in to see me before he received the letter and said: "Don't send it." His arguments were compelling. He explained that we already had received the budgetary allocation to do the scale-up. The money was there. To defer at that point would raise questions of credibility. So, we did go into the semi-works stage in spite of my views. It turned out that I was right by chance. We lost 3-4 years as a result and had to abandon equipment. An objective examination of the technology would have supported my views. But the company had monies in place for capital equipment. And the culture at the time favored investing large amounts of dollars to speed commercialization.

One can wonder if decisions in some cases are made by some to support career advancement. A model can be hypothesized. To advance into upper management one simply becomes identified with a new, exciting development. The financial support is gained for further development, and that support is used to leverage into other areas. Then, after working from that support, the trick is to get out of the project in time, before it fails, and leave successors to pick up the pieces. I believe that such practices, if they occur, are very wasteful. So much time can be lost. In such cases, I had nothing to show for my efforts.

On the positive side, *TYVEK*² comes to mind. *TYVEK* is a plastic material which, in the form of thin sheets, is incredibly strong, much stronger and lighter than paper. So *TYVEK* is now used as envelopes for shipping materials around the world.

The development of *TYVEK* is a very interesting story in pioneering research. Our original intent in pioneering research was to direct our efforts to fibers. We had a list of goals set down and we achieved many accomplishments. A logical extension of that program was to extend into sheet products. The idea came from management around 1955. The idea was a good one, but for 25-30 years, it was held up as a grand mistake. Why?

Because the economics of the material in comparison with paper were not sufficiently favorable to warrant its use, in spite of the functional benefits. Back in the 1950s, some guy extrapolated to when high density polyethylene (HDPE) would become competitive with paper. He predicted 1980. And he was right. Now this product employs a nice big staff and supports a large infrastructure. It is enormously successful commercially. I am still serving as a consultant on the process.

So, *TYVEK* is a very interesting story. For many, it was regarded as unsuccessful, even though it represented a major technical advance. The product performed. It was of high quality; it was patented and further protected by trade secrets. But it was too expensive. Then market conditions changed and the expensive process became competitive. So, the product had to "wait its time." This project is an example of an idea being pursued tenaciously over a long, long period. Now, it's very successful. It's everywhere.

Interview with Carl S. Carter, Deputy Chief Engineer of Special Technology, Lockheed Advanced Development Company (LADC)

Mr. Carter: LADC, known as the *SKUNK WORKS*³, is now a company. Within LADC, I direct the engineering activity for developing special technology, and report to the director of engineering. The director reports to the president of LADC, who is affectionately referred to as the "head skunk."

The *SKUNK WORKS* operates in very specific ways which have led to many innovative designs for new aircraft. Once given a task, a set of goals is established, and the very best people are picked to work on the project. Various engineering milestones are identified. We set a very aggressive schedule, then set people loose and let them do the job. We delegate responsibility to the individuals doing the job. Bureaucratic processes of management are reduced to an absolute minimum.. We do not have a lot of layers of management. The organization structure is very flat and very wide. Everyone working on the project has access to everyone else. People don't have to go through a chain of command to communicate. The *SKUNK WORKS*

project engineer is responsible for the project until it dies. The project engineer figures out a concept, develops drawings, and then works with manufacturing people to implement the concept. If there are problems found during fabrication, the design engineer works with manufacturing and other engineering disciplines to modify the design. Engineers responsible for the project move with the design into each stage of the project. So, the engineer is very much involved in flight tests. He's there throughout the whole life of the project. There may be 1-2 engineers and an associate typically on each project. The chief has full responsibility and authority to advance the project forward.

Mr. "Kelly" Johnston started at Lockheed Corporation in 1932. He formed the *SKUNK WORKS* in 1943, during World War II. Many important advances in design of military aircraft resulted from his efforts. The P-80 was developed under his direction. It was the earliest operational jet fighter aircraft. Mr. Ben Rich succeeded Mr. Johnston as manager of the *SKUNK WORKS* and during his successful career became president of Lockheed. Mr. Rich is now retired.

The essence of the *SKUNK WORKS* can be described by analogy to a World Series baseball game. The goal of the group is to win in a high pressure situation. So everyone has the mindset to work together in achieving the common goal. With relatively few people involved, each person has to contribute favorably to the situation. So the concept includes getting the best people, guiding them minimally, and then getting out of their way so they can do their own thing. In this regard, the term *SKUNK WORKS* suggests an insulation of individuals against bureaucratic interferences, as well as the building up of a special group of individuals. This was done by Kelly Johnston by fencing off an area with only particular individuals allowed access. That tradition was maintained and elaborated further by Ben Rich.

Similar examples have existed. For example, the work culture at Apple Computer, in the early days, captured this embodiment.

Interviewer: The term *SKUNK WORKS* suggests a messy, untidy environment, with individuals being casual, perhaps

even sloppy about what they do. Yet, I suspect that if I were to view typical areas of your facility, I would not see evidence of untidiness. Certainly, there would be no peanut butter smearings on the bench top. Actually, I would think you have to be incredibly careful and highly structured in what you do.

Mr. Carter: Yes, that is the case. You would see an environment similar to that of a high tech engineering university. It would be well equipped with advanced instrumentation. The key to the culture lies more in its philosophy of action than in the physical environment.

In this approach, it is important to give an individual a very significant job, so the person feels he's playing a key role. The individual must feel good about himself or herself in order to be creative and successful.

It is also important to have state-of-the-art equipment and appropriate technologies available so that individuals can solve problems in the most expeditious manner.

Given these aspects, individuals will feel strongly motivated. At our facility, the official working hours are 7:15 a.m. to 4:00 p.m. Yet if you're here either at 6:00 a.m. or at 6:00 p.m., you will find the facility to be at least half full in terms of staff. People simply enjoy it here. So at our facility, we say: It's not just a job, it's a way of life.

Interviewer: In this environment, is there a lot of pressure to be successful? Does stress go along with the job?

Mr. Carter: There is pressure to accomplish the project goals. But, the pressure does not come from managers overdirecting other individuals. Rather, it comes from a kind of a peer pressure, where individuals lead by setting examples.

As I have said, bureaucracy is a negative factor. Bureaucracy can be manifested in many ways. The government imposes paper work. Excessive constraints can be harmful, especially when they make little sense. You have to keep people insulated from idiotic procedures which are irrelevant. But some, if not many, procedures are necessary. We have project reviews, but we keep the reporting as informal as possible. And, there are some benefits from bureaucracy as well. In our case, bureaucracy has good consequences. People don't "mess

with” us. We have more insulation against interruptions and distractions because of the infrastructure we created.

So, in our context, people are not a problem. People will be creative in a *SKUNK WORKS* setting.

MINICASES

Minicase V.1. New Products Dearth

Scenario. An R&D department is functionally organized within a consumer products company of medium size. The group consists of formulations, process development, evaluations, analytical, and supporting services. Within formulations, attempts have been made to run the groups by projects, but there have been shifting priorities. You are the R&D director and have been receiving increasingly harsh criticism from marketing and sales and now from the CEO—who asked you at the last meeting: “Where’s the beef?” Your department has been responding to sales, manufacturing, and to the CEO in solving a series of plant problems from starting-up a new continuous process. At first, you were the hero, but now that competition is increasing new products activity, you are the villain. But each time you try to sustain a new products effort in formulations, phone calls come from the plant across the street and your staff is diverted. You have a limited staff and you have to respond. WDYD?

Discussion. The trend of R&D having to conduct an increasing level of service work is not uncommon, particularly in support of manufacturing. R&D generally has the highest level of technical skills in the organization; and when critical problems arise, problems that directly affect the bottom line, it is very difficult to avoid calling upon the best available expertise. The problem is exacerbated when downsizing has depleted the R&D staff. To control service-related distractions, a structural intervention may become necessary. The R&D department can be restructured to include a brand maintenance group and a new products group, each having different responsibilities. The brand maintenance group would be responsible for handling service-related problems. The new products group would focus entirely on new product development and would be insulated from service work. Problems may still arise because of downsizing and because of morale problems if new products is perceived to be an “elitist” group.

Minicase V.2. Political Underachiever

Scenario. You are a department head of an R&D division in a large organization and have an individual reporting to you who has been giving you some problems. You are relatively new in your position. The individual has been with the organization for many years. Your subordinate seems to be working near the edge of the minimum that is required to perform—based on your standards. You have been under a lot of pressure to substantially increase performance in your area and have created what you feel are reasonable goals to achieve this. Your subordinate always takes time to maintain close relations with managers at high levels in the administration and this makes you feel tentative, even frustrated, about trying to get the proper amount of work from this individual. As a result, you and others have to work harder. The pressures continue to increase. WDYD?

Discussion. Power within organizations can be accumulated by individuals by various methods. One of these is by centrality, that is, the closeness of an individual to the power centers within the organization. This can present a serious problem, especially when the individual underachieves. In time, such political ploys tend to be recognized for what they are. In any event, it may be advisable that the department head should also exercise political skills, and given a stronger power base of position authority, that is likely to be successful in defusing the situation in the long run.

Minicase V.3. The Right Personality

Scenario. You are required to build a department of engineering professionals and are moving forward with staffing at the beginning of your fiscal year. You like to interview candidates yourself, then pass them along to your boss and to others to get feedback. Your boss, the president, likes individuals who are highly assertive and outgoing. You feel more comfortable with individuals who are a little more “lay back.” As you interview candidate after candidate, you become more and more frustrated. The individuals you like are not liked by your boss. You wonder if you should go against the grain or simply go along or compromise somehow. WDYD?

Discussion. Wherever possible, it is desirable to obtain consensus on any important decision within an organization. However, there are occasions where an impasse occurs and individuals become compelled in the interest of time to make the best possible decisions. And frequently, managers will be told: “You decide,” when they seek advice from higher levels of managers. But, when they ask for advice and receive input that is considered contrary

to their wishes, they must also be prepared to deal with the dilemmas that arise. Ideally, the manager should not submit a candidate to a higher level of management unless the candidate is considered acceptable, but acceptable to whom?

Minicase V.4. Conversation in the Washroom

Scenario. You're an executive in charge of R&D for a small firm engaged in marketing lines of cosmetics. One Friday afternoon, as you were washing your hands, the marketing vice president comes by and asks who you pick to win the Bears' game this Sunday. You respond with the usual chitchat. Then he says quite casually: "Oh, by the way, the big boss asked me to tell you that your operating budget for next year is due first thing Monday morning. The time has been moved up so we can review and revise before submitting to corporate headquarters." Then he left for the weekend and you began to wonder. You have had some problems with the marketing vice president, so you wondered if the new time was factual. If you worked on the budget, you would have to scrub your important plans for the weekend. If you didn't work on it, you might be embarrassed Monday morning. You found out later that your boss, the CEO, was out of the country for the weekend and couldn't be reached. WDYD?

Discussion. The problem is that there is no mechanism for the R&D executive to test the validity of what he has been told, at least not until it becomes too late to meet the deadline. It might be decided that even if the weekend becomes "lost" to go ahead and develop the budget anyway. If the assignment was genuine, the deadline would be met. Even if the assignment was a bogus one, the R&D executive would be further along on finishing the budget. In any event, any "gamesmanship" would likely be uncovered.

Minicase V.5. Greasy Kid Stuff?

Scenario. You are the CEO of a company that manufactures and markets a line of household products, including floor finishes (waxes). Under a high priority project with extremely tight time frames, your R&D director had been asked to have a product in commercial production by the end of the month. The R&D director comes to you and reveals a problem has arisen. The new product has looked superb in all tests, but just yesterday, in one of the floor tests, a test area down for four weeks seemed to be becoming slightly more slippery. The surface was checked by the R&D director personally and was found to be noticeably more slippery but not extremely so. It was indicated that the product could be reformulated, but that at least six months would be required before a new formulation could be available.

The R&D director has had an excellent track record with your firm. But, there have been extraordinary pressures on this project. The new product is supposed to be on the store shelf next month, and marketing and sales managers have been very vocal in wanting the product to be available on time. WDYD?

Discussion. In this case, the decision rests on one's attitude toward risk in the face of uncertainty. The level of "slipperiness" seems to be in a "gray area." Many would not risk going forward even with loss of credibility because consumer safety might be involved. There is the possibility of increased liability. In general, it is desirable to avoid potential problems even when uncertainty exists, especially when product safety is at issue. Given that a high level trust has been built between the CEO and the R&D director, the CEO would tend to support the R&D director's recommendation.

NOTES

1. See Crawford (1991, p. 44) for a discussion of "product innovation charters."
2. *TYVEK* and *KEVLAR* are registered trademarks of Du Pont Company.
3. *SKUNK WORKS* is a registered trademark of Lockheed Corporation.

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CASE 6. NEUTROGENA CORPORATION: AN IMPERATIVE FOR ACTION

In looking back at FY 1991, Lloyd E. Cotsen, chairman and CEO of Neutrogena, expressed pleasure with the improved results. He noted that, while 1991 had been a difficult year with a tough economy and increasing competition, "Neutrogena did achieve a new record year in sales, and showed respectable growth in earnings" (p. 2).¹ The more positive results came after a down year. In 1990, there was a downturn in stock, a flattening of sales, an earnings drop, and executive turnover.² Coming out of a more favorable 1991, Cotsen expressed optimism and targeted "Neutrogena's business to increase substantially in sales as well as earnings over the next four or five years" (p. 3).¹

The reasons for Cotsen's optimism were three-fold: first, from the additions of Allan H. Kurtzman as president and chief operating officer (rejoining Neutrogena from Max Factor) and Sheldon L. Zimble as executive vice president (from Procter and Gamble). These additions were designed to strengthen Neutrogena's marketing and sales management teams. The second cause for optimism related to emerging opportunities for globally expanding the Neutrogena brand through the efforts of Christian A. Barden, president of Neutrogena's international division. The third reason was from a special "focus on new products by building stronger research and development and marketing teams to introduce products that will fit our consumer brand image yet broaden our consumer reach" (p. 3).¹

Allan H. Kurtzman's observations in the 1991 annual report echoed Cotsen's sentiments in predicting growth for Neutrogena. Kurtzman indicated that "fully realizing the potential inherent in the Neutrogena brand name is our first priority" (p. 5).¹ He also affirmed a strategy for achieving the desired growth "through carefully planned new product introductions and better, more cohesive advertising." According to Kurtzman, Neutrogena will "succeed by placing more importance on the needs of our retail customers and by developing stronger promotions that are consistent with the Neutrogena image and the value customers have come to expect from us" (p. 5).¹

BUSINESS PROFILE, PRODUCTS, AND FINANCIAL DATA

Neutrogena Corporation manufactures and markets a wide variety of quality skin and hair care products.³ The reputation of the firm and the quality image of the Neutrogena name are key elements in the ability to sustain premium prices in marketing. The company's products are, with one exception,

Exhibit V.1. Description of Neutrogena Skin Care Products²

BAR SOAPS: *Neutrogena* Original Formula, Dry Skin Formula, Baby Cleansing Formula, Oily Skin Formula, Cleansing Bar for Acne-prone Skin: "mild and transparent, most available fragrance-free."²

LIQUID *NEUTROGENA*: "extra mild facial cleanser."

NEUTROGENA CLEANSING WASH: glycerine enriched to cleanse skin irritated by drying medication."

NEUTROGENA NORWEGIAN FORMULA HAND CREAM: "designed to overcome the problems of severely chapped hands."

NEUTROGENA NORWEGIAN FORMULA EMULSION: "hand and body moisturizer that conditions skin."

NEUTROGENA NATURAL SESAME BODY OIL: "the sensual moisturizer that vanishes instantly into shower-damp skin."

NEUTROGENA RAINBATH SHOWER AND BATH GEL "for softening and smoothing the skin while cleansing."

NEUTROGENA MOISTURE: "non-comedogenic facial moisturizer."

NEUTROGENA DRYING GEL FOR ACNE-PRONE SKIN.

NEUTROGENA ACNE MASK: "oil-absorbing clay mask preparation containing benzoyl peroxide."

NEUTROGENA BODY LOTION: "for skin conditioning."

NEUTROGENA LIP MOISTURIZER: with a sun protection factor (SPF) of 15."

NEUTROGENA LEURES/LIPPEN/LABBRA: "lip moisturizer sold in the Common Market."

NEUTROGENA EYE CREAM: "formulated safe enough for even contact lens wearers."

NEUTROGENA NIGHT CREAM: generous moisturizing that's lighter and safer."

NEUTROGENA MOISTURIZER SPF 15 FORMULA UNTINTED AND *NEUTROGENA* MOISTURIZER SPF 15 FORMULA WITH SHEER TINT: "safe and effective facial moisturizer."

NEUTROGENA SUNBLOCK: "PABA-free, waterproof sunblock with a sun protection factor (SPF) of 15."

NEUTROGENA EYE MAKEUP REMOVER GEL: "gently rinses away even waterproof mascara."

(continued)

Exhibit V.1. (Continued)

NEUTROGENA ANTISEPTIC CLEANSER FOR ACNE-PRONE SKIN: "alcohol-free, fragrance-free."

MELANEX TOPICAL SOLUTION: "prescription product used as an aid in the removal of dark skin spots."

T/DERM TAR EMOLLIENT.

VEHICLE/N AND *VEHICLE/N* MILD: "alcohol and water-based solutions for dissolving dermatologically active drugs, as prescribed by a physician."

non-prescription items that are sold over the counter in a variety of outlets, including drugstores, mass volume retailers, food stores and supermarkets, wholesale membership stores, department stores, and other retail outlets. Sales are conducted throughout the United States and increasingly to certain foreign countries. International sales in 1991 represented 20 percent of total sales, up from a levels of 15 percent in 1990 and 11 percent in 1989. The improved performance for international sales in 1991 resulted in positive operating profits for that business segment, compared to operating losses in 1990 and 1989. In 1990, the operating loss of \$1 million for the international segment was attributed to significant losses in Japan and to severance payment to an international division executive.

The company's mix of products includes skin care products (at about 70% of sales) and hair care products (at about 30% of sales). The variety and presentation of products are shown in Exhibits 1 and 2. Perhaps Neutrogena is best known for its Original Formula Bar Soap, which has properties keyed to the concept of gentleness to the skin. The soap is transparent, mild, non-drying, hypo-allergenic, and available fragrance-free. The soap is also described as being "non-comedogenic," that is, will not clog pores or cause blemishes. Many of these properties derive from the presence of high levels of glycerine in its formulation and manufacture. Glycerine has been shown to be high in effectiveness as a moisturizing agent in various formulations.⁴ The transparent appearance and the positioning of the soap bar makes this product virtually unique and distinctive in the marketplace. Neutrogena, as a marketing strategy, has built and continues to build upon this "Neutrogena concept" as it expands its product offerings.

All of Neutrogena's current products were developed through its internal R&D efforts. Research and development costs in 1991, 1990, and 1989 amounted to \$2,045,000, \$1,945,000, and \$1,259,000, respectively. In addition to internal R&D, there is also funding of research to outside experts for various studies, including for support of product claims.

Exhibit V.2. NEUTROGENA HAIR CARE PRODUCTS²

NEUTROGENA SHAMPOO: "extra mild formulation with superior rinsability."

NEUTROGENA CONDITIONER: "for oil-free, clean conditioning."

NEUTROGENA SHAMPOO FOR PERMED AND COLOR TREATED HAIR AND NEUTROGENA CONDITIONER FOR PERMED AND COLOR TREATED HAIR: "gently cleans and moisturizes fragile chemically treated hair."

NEUTROGENA T/GEL THERAPEUTIC SHAMPOO: "removes itching and flaking from psoriasis, dandruff or seborrheic dermatitis."

NEUTROGENA T GEL CONDITIONER: "extends the therapeutic action of T/Gel shampoo."

T/GEL SCALP SOLUTION: "relieves crusty scalp build-up from psoriasis, dandruff, or seborrheic dermatitis."

T/SAL SHAMPOO: "relieves severe crusty scalp build-up from psoriasis, dandruff, or seborrheic dermatitis."

Selected financial data are given in Exhibits V.3 and V.4. The overall compounded growth of Neutrogena, in terms of sales and net income, has been at the rate of 22-23 percent for the period between 1981-1991. Total assets also increased at a 24 percent growth rate. Sales increases of \$21.4 million, up ten percent in 1991, compared to 1990, resulted from several factors. There were price increases of \$13.4 million, an increase of new product sales of \$3.7 million, an increased sales volume of \$3.6 million, and \$0.7 million additional from a favorable fluctuation in foreign exchange rates. In 1990, the sales increase of \$6.6 million, up only 3 percent compared to 1989, resulted from price increases of approximately \$7.4 million, new product sales of about \$7.2 million, sales of trial size products of \$3.3 million and a positive benefit from foreign exchange rates amounting to \$2.4 million. However, those positive increments in sales for 1990 were partially offset by a decrease in unit sales of seven percent (\$3.7 million) to yield the \$6.6 million net sales figure. The lower unit sales volume in 1990 was primarily attributed to a 29 percent unit volume decrease in shampoos and conditioner sales (Exhibit V.4). Considering liquidity and capital resources, the company increased its holdings of cash and temporary investments by \$22.5 million (up 70%) to yield a total of \$54.7 million by the end of fiscal 1991.¹ This increment was primarily due to cash provided by operating activities, amounting to \$30.8 million, offset by cash used for purchases of fixed assets (\$4.0 million), and payment of a cash dividend (\$5.3 million). Inventory increased \$3.4 million (20%) in 1991, which was attributed to a positioning for expected sales growth. The increase of accrued liabilities

*Exhibit V.3. Selected Financial Data for
Neutrogena Corporation and Subsidiaries¹*

In thousands, except per share amounts, and employees

<i>Fiscal years ended October 14</i>	<i>\$</i>	<i>1991</i>	<i>1990</i>	<i>1989</i>
Operating Results:				
Net sales	\$	231,257	209,841	203,212
Cost of sales		55,480	55,572	49,593
Marketing and selling expenses		133,209	117,296	99,520
General and administrative expenses		12,299	10,912	11,347
Other income, net		2,575	2,657	1,825
Income, before income taxes		32,844	28,718	44,577
Provision for income taxes		11,495	11,484	17,832
Net income		21,349	17,234	26,745
Net income per share	\$	0.80	0.65	1.00
Cash dividend	\$	0.20	0.20	0.16

Balance Sheet Data at Year End:

Current assets	\$	110,115	81,392	80,397
Total assets		159,784	132,069	125,183
Current liabilities		49,632	38,411	44,348
Long-term obligations		3,703	3,189	2,489
Total liabilities		53,335	41,600	46,837
Shareholders' Equity		106,449	90,469	78,346

Other Data:

Capital expenditures	\$	3,473	9,806	16,444
Depreciation and amortization		4,569	3,914	2,811
Number of employees at year end		719	716	672

(\$5.0 million or 20%) was attributed to increased management bonuses, payments on trade advertising, and more aggressive use of consumer coupon and rebate promotional programs. Shareholders equities increased \$16.0 million (18%) in 1991 primarily from the net income achieved, partially offset by the dividend. The company's board of directors has increased to 1,000,000 shares of company common stock as the number of shares the company is authorized to purchase in the open market. In 1991, the company had purchased 25,000 shares for \$3 million so that its total holdings of treasury stock were 175,000 shares at October 31, 1991.

Exhibit V.4. Neutrogena Corporation's Sales by
Product Category and by Division¹
(Year ended October 31)

	1991		1990		1989	
Dollars in thousands	Net Sales	Percent	Net Sales	Percent	Net Sales	Percent
<i>Product Category:</i>						
Skin care products	\$ 157,724	68%	\$ 147,613	70%	\$ 140,762	69%
Hair care products	73,533	32	62,228	30	62,450	31
Total	\$ 231,257	100%	209,841	100%	\$ 203,212	100%
<i>Division</i>						
Domestic	\$ 184,136	80%	\$ 178,179	85%	\$ 179,848	89%
International	47,121	20	31,662	15	23,364	11
Total	\$ 231,257	100%	\$ 209,841	100%	\$ 203,212	100%

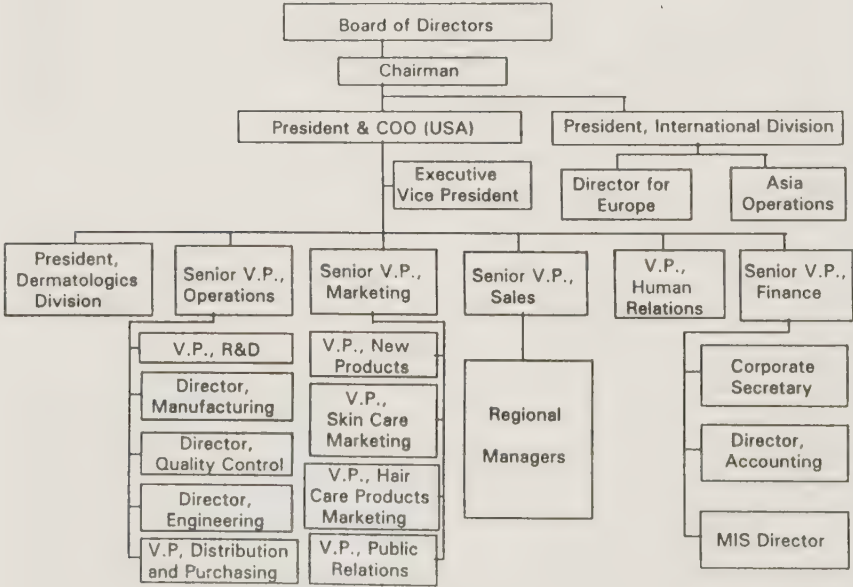


Exhibit V.5. General Organization of Neutrogena Corporation
(Fall 1991) (Schematic)

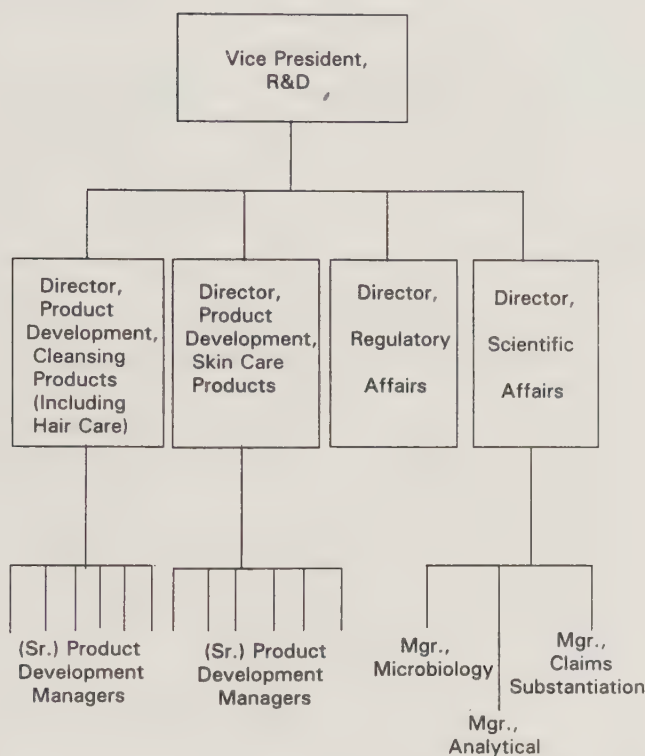


Exhibit V.6. R&D Organization at the Neutrogena Corporation (Fall 1991) (Schematic)

ORGANIZATIONAL ASPECTS AND R&D FUNDING

The general organization of the company (in 1991) is given in Exhibit V.5, and the R&D organization is described in Exhibit V.6. In 1991, R&D moved to a dual reporting relationship. Rolf Mast, vice president of R&D, began to report administratively to the senior vice president of operations; but on product matters, he reported to the new president and chief operating officer. The staff of R&D in 1992 totaled 25 individuals, up substantially from the levels of 11-15 during the period between 1983-1987. The four operating areas within R&D are product development for cleansing products (including hair care), product development for skin care, regulatory affairs, and scientific affairs. Each area is headed by a director who reports to the vice president of R&D.

In reaching its present configuration, R&D has evolved through various stages. Originally, R&D and quality control were part of one department, which was called the technical department. That department was headed by Eric Jungermann, who also served, as the senior technology consultant for the corporation. During the period between 1983 and 1987, the staff of the quality control department grew from 12 to 24 individuals and in 1991 the staff grew to 27. During the 1980s, quality control grew at a faster rate than R&D. Quality control is closely tied to production volumes, the number of lines operating, the number of shifts, etc.

Expenses for R&D have generally increased fairly consistently over the period from 1984 through 1991 (Exhibit V.7). However, in relation to sales growth, the spending for R&D (as percentage of sales) actually decreased between 1984 and 1988, then has increased from 1988 to 1991. The R&D expenditure for 1988, at 0.53 percent of sales, was at the lowest level during that period of time. The average level of R&D expenses for Neutrogena, from 1984 through 1991, was 0.8 percent of sales. At the level of 0.9 percent for R&D (as percentage of sales) for 1990, Neutrogena Corporation ranked lowest with Avon Products (at 0.8%) in R&D expenses *as percentage of sales*, in a comparison of 16 personal care companies (*Business Week*, 1991, p. 176).⁵ However, the 1990 sales reported for Avon Products was approximately \$3,454 million, compared to 209.8 million for Neutrogena.⁵

TECHNICAL ACTIVITIES

The key activities of the R&D department encompass new products development, new technologies/new processes, brand maintenance, regulatory affairs, and technical services. In addition to these, R&D continues to have an "oversight" responsibility for helping the company maintain its quality assurance protocols.

Exhibit V.7. Selected Data for Technical Effort at Neutrogena

<i>Year</i>	<i>Net Sales (millions)</i>	<i>R&D Expense (millions)</i>	<i>R&D Expense (% of sales)</i>	<i>R&D Personnel (at year-end)</i>	<i>Quality Control Personnel</i>	<i>Net Income (millions)</i>
1984	\$ 59.2	\$ 0.64	1.08%	11	13	\$ 4.2
1985	74.5	0.75	1.00	13	15	6.2
1986	96.0	0.74	0.77	14	17	8.1
1987	135.1	0.86	0.64	15	24	14.9
1988	178.9	0.95	0.53	not known	not known	23.0
1989	203.2	1.26	0.62	not known	not known	26.7
1990	209.8	1.94	0.93	not known	not known	17.2
1991	\$ 231.3	\$ 2.04	0.88%	25	27	\$ 21.3

New Product Development

The development of new products continues to be a key responsibility of the R&D department. During the period from 1983-1991, 20 new products were introduced into the marketplace. These products, all developed internally, are listed as follows:

- 1983: Liquid Neutrogena, Moisture,
- 1984: Oily Skin Soap, T/Gel Scalp Conditioner,
- 1985: Acne Mask, T/Gel Conditioner,
- 1986: Emulsion, Sunscreen, Conditioner, Levres,
- 1987: Unscented Liquid Neutrogena, Eye Cream, T/Sal,
- 1988: Liquid Acne Cleanser, Night Cream,
- 1989: Neutrogena Eye Makeup Remover Gel, Neutrogena Antiseptic Cleanser for Acne-prone Skin,
- 1990: Neutrogena Shampoo for Permed and Color Treated Hair, Neutrogena Conditioner for Permed and Color Treated Hair, and
- 1991: Neutrogena Moisturizing Face Cream—Dermatological Formula (introduced in France only).

Some of the new products are technically unique and have been patented. Some represent the application of known technologies and others are relatively straightforward line extensions.

The R&D department has had an active patenting program as illustrated by the following list of issued U.S. patents:

- No. 4,290,904: Transparent Soap (issued September 22, 1981),
- No. 4,610,874: Clear Conditioner (issued September 9, 1986),
- No. 4,640,932: Acne Mask (issued February 3, 1987),
- No. 4,678,663: Hydroquinone Composition (issued September 10, 1988),
- No. 4,725,433: Clear Conditioner (issued February 16, 1988),
- No. 4,725,429: Benzoyl Peroxide (issued February 16, 1988),
- No. 4,727,088: Retinoid Composition (issued February 23, 1988),
- No. 4,738,956: Hydrocortisone Conditioner (issued April 19, 1988),
- No. 4,758,370: Continuous Soap Manufacture (issued July 19, 1988),
- No. 4,820,508: Sun Screen (issued April 11, 1989),
- No. 4,822,600: Sun Blocker (issued April 18, 1989),
- No. 4,839,080: Antibacterial Soap (issued June 13, 1989), and
- No. 4,894,222: Sun Screen (issued January 16, 1990).

In addition to the new products, the company has also introduced some line extensions and reformulations which are worthy of note. Untinted

Neutrogena Moisture SPF 15 Formula was introduced in November 1989 as an extension of the sheer tinted formula. Neutrogena Moisture SPF 15 Formula with sheer tint and Neutrogena Sunblock were reformulated and relaunched in 1990 and in 1991, respectively. These developments reflect the company's continuing emphasis on quality and on the Neutrogena image.

New Technologies

The R&D department has developed a new process for the continuous manufacture of Neutrogena soaps. That process provides the company with an option for replacing the traditional batch manufacturing process. Patent applications have been filed and several claims have been allowed for the new process. This new development permits greater production capacity, further quality improvement, and more favorable economics of production. Exhibit V.8 schematically describes the new process, which includes two key elements: rapid saponification through static mixers, and continuous cooling and preforming of soap. R&D successfully demonstrated the feasibility of the new process in various pilot plant and plant-scale experiments.

In a second area of technology development, R&D has made substantial strides in developing new methodologies for use in substantiating product claims. New techniques have been developed for measuring soap

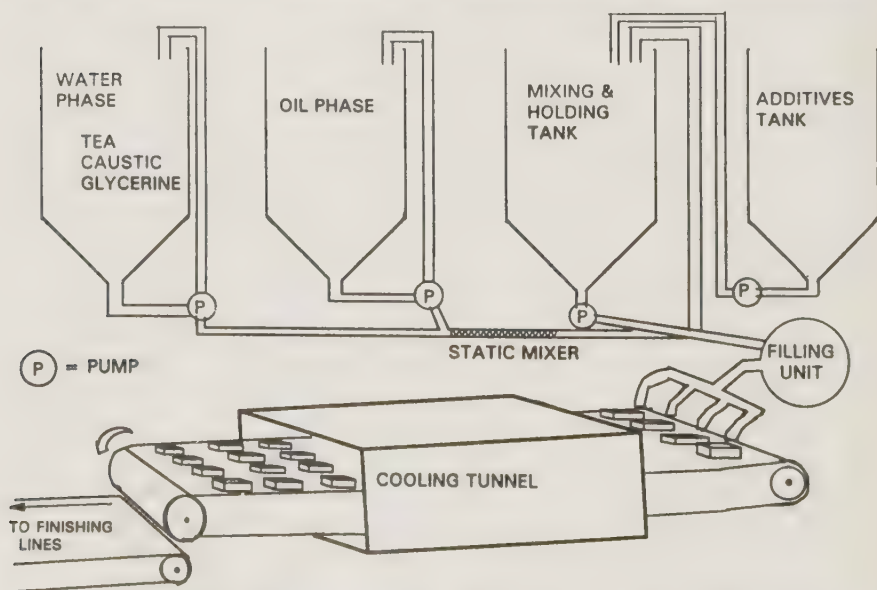


Exhibit V.8. Schematic of Continuous Saponification System

rinsability, shampoo rinsability, and longevity of moisturizing effects. These techniques have provided support for advertising.

R&D generally has responsibility for seeking and exploring newly emerging technologies and materials to keep the company at the forefront of technology.⁴ For example, R&D has maintained active screening programs for biopolymers, cytokines (metabolism control agents), arachodonic acid metabolites (possible anti-psoriasis agents), encapsulating agents, anti-aging ingredients for skin beneficence, etc. These efforts are part of a continuing program of exploratory research aimed at uncovering new, interesting possibilities.

Brand Maintenance

This term covers the system of activities involved in protecting the present lines and brands of the company. It includes such activities as development of line extensions, minor product extensions, resolution of raw material supply problems, and monitoring and follow-up of competitive activities.

Regulatory Affairs

R&D has responsibility for handling matters relating to both federal and state regulations, domestically and internationally. Those activities involve keeping abreast of FDA regulations and monographs, keeping appropriate records, monitoring protocols, and preparing for possible INDs (Investigative New Drugs).

Technical Services

As business volume has grown, the activities of technical services have also grown within R&D. Technical services are provided to operations, to marketing and sales, to public relations, and to the international division. As examples, R&D supervises new product runs in the plant, it reviews advertising copy for marketing, it participates in sales training activities, it conducts presentations to consumer groups and to beauty editors, and it provides a broad range of activities (up to 20% of the total R&D effort) for the international sector.

Quality Assurance

Given that Neutrogena charges premium prices for its products, the operating philosophy throughout the company is that quality is a key corporate concern. Quality is considered to be the responsibility of everyone from top management down to the junior quality control inspector and

worker on the manufacturing line. The company's quality assurance program has evolved from R&D since both R&D and quality control (Q.C.) were part of the technical department. The technical department created and supervised the original Q.C. protocols for testing of incoming raw materials and packaging materials, for in-process and finished product testing, for documentation and record-keeping, and for updating specifications. Since 1990, the quality control department has been the responsibility of the operations division. R&D also reports administratively to operations and provides support to Q.C. by problem solving and by phasing in new methodologies. Efforts for quality have increased substantially in the company and particularly in providing releases for over the counter (OTC) drugs, an important marketing area of the company. OTC products are covered by FDA regulations.

There have been some threats emerging, some regulatory and competitive issues, which have had to be addressed by the R&D department. For example, in 1988, 85 percent TEA (triethanolamine) came under scrutiny by various regulatory bodies. R&D had to be "on top of" this problem and had to reformulate certain products, substituting the more acceptable 99 percent pure TEA. A new TEA-free transparent soap formulation was also developed which retained all positive attributes of Neutrogena soap.

Competition

Interest in skin care has been expanding throughout the personal care, health care, and cosmetic industries. That interest is manifested by the growing number of new product offerings for skin care.^{6,7,8,9} Innovations promoting the mildness theme have proliferated for both the bar and liquid soap markets.⁶ In the field of color cosmetics, products are not just used for makeup anymore. They are also expected to have a skin-enhancing effect. Skin enhancement includes moisturization and protection against the sun's harmful rays.^{7,8} There is a renewed emphasis on "naturals" in the 1990s.⁹ These trends tend to increase competitive pressures on Neutrogena product lines and, perhaps, create new opportunities for the company.

Neutrogena competes with some serious "players." Some are very major companies. For example, there are the major soap companies, Procter and Gamble, Colgate-Palmolive, Lever Brothers, and The Dial Corporation. Several high quality soaps, containing either high glycerine levels or special mildness ingredients, have appeared on the market. Dial's *Nutrelle*, P&G's *Monchel*, P&G's *New Formula Camay*, and *Lever 2000* are representative of some soaps that can impact competitively.¹⁰ In the hair care area, competitors have introduced claims similar to Neutrogena's rinsability and anti-buildup claims. Revlon has introduced a water-clear conditioner and a "*Clean and Clear*"¹⁰ shampoo which challenge the Neutrogena shampoo

products. In the skin care area, formidable competition comes from many sectors and particularly from the leading product, *Vaseline Intensive Care Lotion* (from Chesebrough-Ponds, now part of Unilever).¹⁰

Accordingly, competition with Neutrogena's products comes from many sectors, that is, from the soap and detergent industry, from the cosmetics industry, from the health care industry, and so on. Companies strongly engaged in health care and pharmaceuticals, for example, Revlon and Warner-Lambert, could compete effectively by drawing upon on a much larger base of R&D (ranging, for example, from 4-7% of sales for R&D expenditures) in contrast to Neutrogena.^{11,12}

Also, on the other end of the business, that is, in the area of "contract sales," a number of private label houses have come out with excellent duplications or close facsimiles of some Neutrogena products.

All these competitive challenges have to be met while the company is striving to achieve its ambitious goals.

AMBIENCE AND CULTURE

A visit to the corporate offices of Neutrogena is an interesting experience. As with many California companies, the atmosphere is friendly and informal. Beyond that, the offices of the company are distinguished by having an extraordinary collection of art and sculptures of the Southwest, accumulated by Cotsen. It seems to a visitor that the art and the culture of the company mirror one another. The images suggest an interesting combination of quality and naturalness that is also communicated in the way the company's products are presented.

Interviews

The operating culture of the company was also tapped by conducting interviews with key R&D executives, namely Eric Jungermann and Rolf Mast. Each was asked to consider what facilitates and what impedes technical creativity and innovation.

Interview with Eric Jungermann, Senior Staff Vice President of Research and Development for Neutrogena Corporation and President, Jungermann Associates, Inc.

Dr. Jungermann: In terms of what helps people to be creative, technically, my answer to that question naturally reflects my experience in an industrial R&D environment. First of all, I think it is important

to give individuals plenty of chances to be exposed to ideas and to the literature. I do my best work after reading the literature and attending technical meetings. That includes having discussions with peers.

A second element of importance is having a balanced atmosphere: one in which supervision is given so that individuals are not overwhelmed, and one in which individual action is encouraged. You can't be directing people all the time. Yet, it is important for people to be able to come to your office and get help. You have to balance it out.

The R&D managers also play an important role in balancing the amount of technical service work that is done, in contrast to new products R&D. The reality of the industrial world is that "firefighting" is easier and more straightforward than new product development. So people lean towards it. And R&D does, indeed, have to do technical service work. R&D supports our manufacturing operations. There is also a tremendous emphasis on quality at Neutrogena, and R&D is responsible for overseeing product quality.

But, you also need to reserve and insist on people having time for new products. It is the vice president's responsibility to set the tone. The R&D directors also have to understand this as well. The problem is that technical service work provides instant gratification, as opposed to doing something which may never work in the future. Unfortunately, people gravitate to the routine. It's a dilemma. You can't win. The vice president of R&D can't tell corporate management that new products can't be developed because plant problems are being solved. You have to be good at both activities.

Interviewer: Isn't the problem solved by organizationally separating new product development people from technical service people, and then insulating them from routine "firefighting?"

Dr. Jungermann: Organizational "fixes" don't usually work. What happens is that new products people have

to get their products into the plant through the cooperation of production people. So, inevitably, the new products people become more involved with handling production problems. That progression can interfere with new products R&D, especially when your staffing capabilities are limited.

It's also important to make sure you hire the right mix of people. You need idea people, the creative types, who can generate ideas. But, you also need the implementers, the fixers, who make sure that things keep running and running well.

Interviewer: What gets in the way of technical creativity?
Dr. Jungermann: In the consumer product environment, there is a great temptation for the boss and marketing, and your peers outside of R&D, who are likely to be non-technical, to insist on short-term activities. They may not allow sufficient effort to be spent on longer-term projects, which could have a greater impact on the business. So, a short-term perspective, when it is excessive, is a serious barrier.

A second problem arises because humans tend to believe in hierarchical relationships. For example, if by chance I were to meet a Ph.D. professional in the hallway, I might ask: What are you working on? Then I might casually say: Why don't you try such and such? Then later, I might realize that the idea was silly, that it wouldn't work. But I would also hope that an R&D professional would realize that and would not try it. But, to my dismay, I have found that because of my position, the researcher feels that the suggestion has to be followed. And, of course, after it doesn't work, the researcher makes a point of telling me so. I believe that such hierarchical responses are bad. It's a cultural thing.

A similar cultural impediment arises as one travels to different countries as a technical consultant. In the United States, it is common that people embrace the "Protestant" work ethic and will simply attack a problem by trying to solve it. That is really an effective approach. But in

some other cultures, I am regarded as an expert who is expected to know an answer to a problem without the benefit of any data. For example, I might be told that because of altering ocean currents, the fat composition of fish oil is changing. I am then asked what formula do I recommend for a particular product in light of that? And, of course, I have to ask that a simple analysis be performed in order to determine the composition of the fish oil, from which I can then recommend a formula. So, one can encounter different work ethics where even the scientific method is not always appreciated. And, sometimes that attitude, that a so-called expert should even have answers without data, is even encountered in the United States.

Interviewer: I have heard that in some organizations, hierarchical barriers are overcome and top R&D managers and researchers will sit down as peers to discuss problems. Can't that dynamic help in expediting research?

Dr. Jungermann: Yes, that is true. The V.P. of research could converse with scientists in an informal way. Unfortunately, the V.P. is generally so busy handling corporate "political" problems and attending multiple meetings, that such conversations are done "on the run." You also have to look at the organization's senior chemists. Those individuals should know more about their research than the managers. And the research managers should know more than the vice president. Some vice presidents do give too much advice. I have always been "hands-on" in my approach. But most vice presidents simply do not know about research details. They are too busy with politics, as I have stated, and they essentially are managing "from a distance."

There is another issue in the domain of R&D management which deserves some attention. Based on a Harvard study, CEOs have been encouraged to believe that a good manager in one discipline will generally be a good manager of another discipline. So the argument is that it's

more important to have good managerial skills than to have the specific expertise or knowledge of the domain you are managing. But to me, if you're a research manager, you also have to be a good research person. You have to be able to understand science and technology well enough from education and experience to be able to guide the R&D effort effectively. I know of organizations which have placed non-technical individuals in charge of R&D. Such individuals have come from finance or from materials management, as examples. The practice doesn't work well in the long term. One major problem that arises is the problem of credibility. Research scientists tend to question the ability of non-technical managers to manage the technical dimension. So there is a credibility gap which can erode the situation. That gap can only be bridged if the research manager has convincing technical credentials.

Interview with Rolf Mast, Vice President of Research and Development, Neutrogena Corporation

Dr. Mast: In my experience, the biggest single issue relating to R&D management is the problem of short deadlines. That's the biggest barrier to technical creativity that I know. Actually, it's important to recognize that there are two types of creativity relevant. One type involves relatively little that is new in technology. For example, someone may want to consider selling water for spraying on the face to provide moisturizing to the skin. For such an example as this, the required product development time would be zero. On the other hand, there would be a need for creativity in packaging and claims. That type of creativity is actually enhanced by deadlines. On the other hand, longer-term and more complex efforts for obtaining significant technical accomplishments are actually impeded by having short-term deadlines. So deadlines can have different effects, positive or negative, depending on what is the complexity of what you're trying to do. I separate the two areas, longer-term product development and shorter-term project support, as distinctly different levels.

Which level it is that you work on is driven by top management decisions.

At the present time, top management is looking to substantially expand our product line through a process of creative repositioning. I have to be able to shift gears as needed, and I have to rely on my research directors for support. When heading an R&D group, you have to be aware of what is needed and to be able to build the organizational structures needed to respond appropriately.

There are two important issues given these demands. One is that it is very essential to maintain technical and legal "integrity." By integrity I mean all the elements that make our products safe, effective, and of the highest quality. You must make sure that deadlines do not have the effect of compromising that integrity in any way. And management expects that I will always maintain product safety and efficacy even with short deadlines in other areas.

A second issue relates to the need to be able to sustain R&D in new areas which are not necessarily driven by marketing. R&D has a continuing responsibility to keep the company aware, and at the forefront, of new science and technology that is emerging in relevant industries. So you can't only work on short-term activities even if you wanted to. Working only for the short-term inevitably means that your organization will eventually miss longer-term opportunities, opportunities which will become next year's priorities by all concerned.

Interviewer: What about R&D of an exploratory nature? Do you have to "bootleg" research time in order to explore less immediate opportunities? By bootlegging, I don't mean it in a negative sense.

Dr. Mast: I actually don't have the luxury to engage in bootlegged research. I don't see any moral conflicts with bootlegging. We just don't have the time. What we do, how we manage our time, is almost like a balancing act. When there is new technology hitting the marketplace we have to evaluate it. For example, there are new sun blockers and new OTC [over the counter] monographs emerging. We have to keep abreast of these developments.

Right now, we are under a lot of pressure because of new initiatives. Allan Kurtzman is our new COO [chief operating officer]. He was with Neutrogena in the mid-1980s, then moved to Max Factor. He has returned to our

firm with a specific agenda. His goal is to double the business in four years time. This goal has been stated publicly by our new COO. So we will have to maintain progress in order to do that.

Our structure in R&D is functionally oriented. We have four groupings within a staff totalling 25 individuals. The groupings include: skin care research, product development, hair care research, and support services. Within support activities, we cover microbiology, analytical support for product claims, functionality testing, and product safety. The balance of emphasis is maintained by communications on a day-to-day basis. Communications within R&D are very important. Recently, we have been holding eight meetings per month (two per week). This was too many. Now we are trying out the approach of having one long formal meeting each month. The monthly meetings are being scheduled formally. In addition, we will hold more ad hoc meetings which will address specific issues as they arise.

Interviewer: What helps individuals to be creative, in a technical sense?

Dr. Mast: As I mentioned earlier, there are two levels of creativity, relating to the short term and to the long term. Each level is influenced in different respects by various environmental factors. Outside of these two levels, the way people react to certain factors is dependent on the character of the individuals involved.

It is important to recognize that creativity can be demanded. Top management can challenge and query individuals at initial presentations of their work. That challenge stimulates individuals to respond and they become more creative in the process, but only if the challenge presented is balanced so it is not perceived to be a severe threat. In our case, the COO is equated with top management.

Interviewer: How might the COO challenge an individual to be more creative? What is the process?

Dr. Mast: For example, let us say that you are presenting a newly developed product, one which is a skin moisturizer, to the COO. He can challenge you on all sorts of issues, on claims, on new raw materials, on marketing position, and so on. He will not rest content until he sees the effort made and the results which successfully differentiate your products from the competitors' products. And the differentiation must be of the character which is considered to be desirable.

In thinking about creativity, it is also very important to have the right people involved. Creative people are born with a high level of energy and are highly flexible in their way of thinking. I do not think you can teach this capability, although you can enhance it in people who already possess the potential for being creative.

CASE NOTES

1. See the *Neutrogena 1991 Annual Report* (for the fiscal year ending October 31, 1991).
2. See the *Neutrogena 1990 Annual Report*. Note for exhibits 1 and 2 and in other areas of this material: *Neutrogena*, *T/Gel*, *T/Sal*, *Rainbath*, *Neutrogena Moisture*, *Melanex*, *T/Derm*, *Neutrogena Norwegian Formula*, *Smile*, *Vehicle/N*, and *Neutrogena Leves/Lippen/Labbra* are registered trademarks of Neutrogena Corporation.
3. Form 10-K for Neutrogena Corporation, Commission File Number 0-7623, for the fiscal year ending October 31, 1991, Securities and Exchange Commission.
4. For a more detailed glimpse into relevant technology, see Jungermann, E., & Sonntag, N.O.V. (Eds.) (1991). *Glycerine: A key cosmetic ingredient*, Volume 11 of *Cosmetic Science and Technology Series*, New York: Marcel Dekker, Inc.
5. Selected R&D funding data from *Business Week*, (1991). Quality in R&D, October 25, pp. 147-216.
6. See Kintish, L. (1991). Updating old standards. *Soap/Cosmetics/Chemical Specialties*, December 1991, pp. 26-28.
7. Note article by Christiansen, S. (1991). Skin treatment cosmetics, *Soap/Cosmetics/Chemical Specialties*, February 1991, pp. 30-36.
8. See article by Kintish, L. (1991). A look at eye treatment, *Soap/Cosmetics/Chemical Specialties*, February, pp. 38-42.
9. See Darconte, L. (1991). Color cosmetics: New decade, new attitude, new naturals, *Soap/Cosmetics/Chemical Specialties*, May, pp. 31-34.
10. The products noted in this case, that represent trademarks by other companies, are: *Nutrelle* (a trademark of The Dial Corporation), *Monchel*, and *Camay* (trademarks of Procter and Gamble), *Lever 2000* (a trademark of Lever Investments Corp.), *Vaseline Intensive Care Lotion* (*Vaseline Intensive Care* is a trademark of the Chesebrough-Ponds, Inc., a division of Unilever United States, Inc.), *Clean and Clear Shampoo* (*Clean and Clear* is a trademark of Johnson & Johnson Consumer Products, Inc., which acquired the product line from Revlon).
11. Revlon spent 4.1-4.5 percent on R&D (based on \$2.3-2.4 billion sales) during the period of 1983-1985 (*Revlon Annual Reports to Shareholders, 1983-1985*). Warner-Lambert spent 4.5-6.5 percent (based on \$3.1-3.2 billion sales) during 1982-1986 (*Warner-Lambert Annual Reports to Shareholders, 1982-1986*). Chesebrough-Ponds (C-P) acquired Stauffer Chemical Corp. in 1985 and was incorporated into Unilever to arrive at a very highly leveraged R&D component. Prior to 1985, that is, from 1977-1984, C-P's R&D expenses ranged from 1.0 to 1.3 percent of sales. During that period, sales ranged from \$669 million to \$1,522 million for C-P (*Chesebrough-Ponds Annual Reports to Shareholders, 1977-1984*).
12. It is noted that, just as this case was receiving its final editorial notes, in October of 1994, the acquisition of Neutrogena Corporation was completed by Johnson & Johnson. Neutrogena Corporation became part of Johnson & Johnson as a subsidiary company. Johnson & Johnson is a manufacturer of health care, pharmaceutical, professional, and consumer products and has a large base of divisional R&D facilities.

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